



Design Partners in
Architecture and Interiors

CITY OF MISSISSAUGA FIRE STATION 123

3050 The Collegeway, Mississauga

Project Number: 12301
Specifications Issued for: Tender

CONSTRUCTION DOCUMENTS PROJECT MANUAL

Volume 2

Mechanical, Electrical, Commissioning

ISSUED FOR TENDER

www.dpai.ca

Design Partners in Architecture and Interiors

25 Main Street West Suite 1800
Hamilton, Ontario L8P 1H1

1 Document Responsibility

- 1.1. *Refer to Project Manual, Section 00 01 10 - Table of Contents, for indication of document responsibility (DR). Abbreviations for entity responsible for document preparation are as follows:*
 - 1.1.1. A - Denotes documents prepared by Architect.
 - 1.1.2. C - Denotes documents prepared by Civil Engineer (Site Servicing).
 - 1.1.3. E - Denotes documents prepared by Electrical Engineer.
 - 1.1.4. M - Denotes documents prepared by Mechanical Engineer.
 - 1.1.5. S - Denotes documents prepared by Structural Engineer.
 - 1.1.6. L - Denotes documents prepared by Landscape Architect
 - 1.1.7. Cx - Denotes documents prepared by Commissioning Agent
- 1.2. *Professional seals if applied next to company names in the project directory (below) govern only those specification sections and schedules identified by the corresponding document responsibility (DR) abbreviation in Section 00 01 10.*
- 1.3. *With regard to Section 00 30 00: The architect's seal governs only Section 00 30 00 proper, and not the documents listed therein.*

2 OWNER

- 2.1. *Owner:*
 - 2.1.1. City of Mississauga
 - 2.1.2. 300 City Centre Drive
 - 2.1.3. Mississauga, ON L5B 3C1
- 2.2. *Primary Contact:*
 - 2.2.1. Title: Project Manager, Capital Design and Construction
 - 2.2.2. Name: Alexis Schneider
 - 2.2.3. Phone: T 905-615-3200 ext. 3395

3 CONSULTANTS

- 3.1. *Architect: Design Professional of Record.*
 - 3.1.1. DPAI Architecture Inc.
 - 3.1.2. 25 Main St W Suite 1800
 - 3.1.3. Hamilton, ON L8P 1H1
 - 3.1.4. Tel: (905) 522-0220
- 3.2. *Primary Contact: All correspondence from the Contractor to the Architect will be through this party.*
 - 3.2.1. Name: Sebastian Lubczynski
 - 3.2.2. Title: Senior Architect
 - 3.2.3. Email: sebastian@dpai.ca
- 3.3. *Structural Engineering Consultant (S):*
 - 3.3.1. LEA Consulting Ltd.
 - 3.3.2. 40 University Avenue, Suite 503
 - 3.3.3. Toronto, Ontario
 - 3.3.4. 416 575 1787
- 3.4. *Mechanical Engineering Consultant (M):*
 - 3.4.1. QUASAR Consulting Group
 - 3.4.2. 250 Rowntree Dairy Road
 - 3.4.3. Woodbridge, Ontario

3.5. ***Electrical Engineering Consultant (E):***

- 3.5.1. QUASAR Consulting Group
- 3.5.2. 250 Rowntree Dairy Road
- 3.5.3. Woodbridge, Ontario

3.6. ***Civil Engineering Consultant (C)***

- 3.6.1. LEA Consulting Ltd.
- 3.6.2. 40 University Avenue, Suite 503
- 3.6.3. Toronto, Ontario
- 3.6.4. 416 575 1787

3.7. ***Landscape Architect (L)***

- 3.7.1. Adesso Design Inc.
- 3.7.2. 69 John Street, Suite 250
- 3.7.3. Hamilton, Ontario
- 3.7.4. 519-616-7076

3.8. ***Commissioning Agent (Cx)***

- 3.8.1. Pradus Group Inc.
- 3.8.2. 213 Sterling Road, Unit 108
- 3.8.3. Toronto, Ontario
- 3.8.4. 416-947-6918

END OF SECTION

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REFER TO CIVIL AND LANDSCAPE DRAWINGS FOR FULL SCOPE OF REQUIREMENTS.

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END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 This Section specifies products, criteria and characteristics, and methods and execution that are common to one or more Sections of Mechanical Divisions. It is intended as a supplement to each Section and is to be read accordingly.

1.2 REFERENCES

- 1.2.1 Division 00 and Division 01 apply to and are a part of each Mechanical Division:
 - 1.2.1.1 Division 20 – Common Mechanical Requirements;
 - 1.2.1.2 Division 21 – Fire Suppression;
 - 1.2.1.3 Division 22 – Plumbing;
 - 1.2.1.4 Division 23 – Heating, Ventilating, and Air Conditioning;
 - 1.2.1.5 Division 25 – Integrated Automation.
 - 1.2.1.6 The provisions of this Section also apply to the following sections:
 - (1) Section 08 31 00 – Access Doors and Panels.
 - (2) Section 10 44 16 – Fire Extinguishers;

1.3 SUBMITTALS

- 1.3.1 Submit shop drawings/product data sheets for:
 - 1.3.1.1 pressure gauges and thermometers;
 - 1.3.1.2 electric motors (submit with equipment they are associated with).
- 1.3.2 Submit weight loads for selected equipment (upon request).
- 1.3.3 Submit copy of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations.
- 1.3.4 Submit a list of equipment identification nameplates indicating proposed wording and sizes.
- 1.3.5 Submit a list of pipe and duct identification colour coding and wording.
- 1.3.6 Submit a proposed valve tag chart and a list of proposed valve tag numbering and identification wording.
- 1.3.7 Submit drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.
- 1.3.8 Submit any other submittals specified in this Section or other Sections of Mechanical Divisions.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- 1.4.1 As specified in Part 2 of this Section, submit a spare belt set, tagged and identified, for each belt driven piece of equipment.

2 PRODUCTS

2.1 FIRESTOPPING AND SMOKE SEAL MATERIALS

- 2.1.1 Firestopping and smoke seal system materials for mechanical penetrations through fire rated construction are specified in Section 20 05 17 – Sleeves and Sleeve Seals for Mechanical Piping, and work is to be done as part of mechanical work unless otherwise specified in Division 07.

2.2 ACCESS DOORS

- 2.2.1 Refer to Section 08 31 00.
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- 2.2.2 Provide all access doors required for Mechanical work unless otherwise specified in Division 08. Coordinate consistency of look and finish of access doors on project with each Division of Work. Coordinate exact requirements with General Trades Contractor.
- 2.2.3 Access doors to be rust resistant steel door panels, with concealed hinges and positive locking and self-opening screwdriver operated lock. Wall type frame to be suitable for wall installation and have integral keys for plaster walls. Doors in tile wall to be stainless steel and in ceilings to be suitable for plaster covering with only frame joint showing. Other doors to be prime painted steel.
- 2.2.4 Size access doors to suit the concealed work for which they are supplied, and wherever possible they are to be of standard size for all applications, but in any case they are to be minimum 300 mm x 300 mm (12" x 12") for hand entry and 600 mm x 600 mm (24" x 24") for body entry.
- 2.2.5 Lay-in type tiles, properly marked, may serve as access panels. Coordinate marking of ceiling tiles with the Consultant. Panels in glazed tile walls to be 12 gauge, 304 alloy stainless steel, No. 4 finish, with recessed frame secured with stainless steel counter-sunk flush head screws.
- 2.2.6 Panels in plaster surfaces to have dish-shaped door and welded metal lath, ready to take plaster. Provide a plastic grommet for door key access.
- 2.2.7 Other access doors to be welded 12 gauge steel, flush type with concealed hinges, lock and anchor straps, complete with factory prime coat. Submit to Consultant for review, details of non-standard door construction details.
- 2.2.8 Access doors in fire rated ceilings, walls, partitions, structures, etc., to be ULC listed and labelled and of a rating to maintain fire separation integrity.
- 2.2.9 Where access doors are located in surfaces where special finishes are required, they are to be of a recessed door type capable of accepting finish in which they are to be installed so as to maintain final building surface appearance throughout.
- 2.2.10 Manufacturers:
 - 2.2.10.1 SMS.
 - 2.2.10.2 Bauco.
 - 2.2.10.3 Acudor.

2.3 FLEXIBLE PIPING CONNECTORS

- 2.3.1 Double wall stainless steel flexible connectors for piping connections to vibration isolated equipment, each selected by manufacturer to suit the application. Shop drawings or product data sheets must indicate construction and performance requirements that suit the application.
- 2.3.2 Manufacturers:
 - 2.3.2.1 Hyspan Precision Products Inc.;
 - 2.3.2.2 Senior Flexonics Ltd.;
 - 2.3.2.3 The Metraflex Co.

3 EXECUTION

3.1 GENERAL PIPING AND DUCTWORK INSTALLATION REQUIREMENTS

- 3.1.1 Unless otherwise specified, locate, and arrange horizontal pipes and ducts above or at ceiling on floors, arranged so that under consideration of all other work in area, maximum ceiling height and/or usable space is maintained. If required to maintain ceiling heights, reroute and/or resize ductwork, with Consultant's approval.
 - 3.1.2 Unless otherwise specified, install work concealed in finished spaces, and concealed to degree possible in partially finished and unfinished spaces. Refer to and examine
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- Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Walls which are painted are considered finished.
- 3.1.3 Install pipes and ducts parallel to building lines and to each other.
 - 3.1.4 Neatly group and arrange exposed work.
 - 3.1.5 Locate work to permit easy access for service or maintenance as required and/or applicable. Locate valves, dampers and any other equipment which will or may need maintenance or repairs and which are to be installed in accessible construction so as to be easily accessible from access doors. Where valves, dampers and similar piping or ductwork accessories occur in vertical services in shafts, pipe spaces or partitions, locate accessories at floor level.
 - 3.1.6 Make connections between pipes of different materials using adapters suitable for application. Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe.
 - 3.1.7 Comply with equipment and material manufacturer's installation instructions unless otherwise specified herein or on drawings, and unless such instructions contradict governing codes and regulations.
 - 3.1.8 Carefully clean ducts, pipe and fittings prior to installation. Temporarily cap or plug ends of pipe, ducts and equipment which are open and exposed during construction.
 - 3.1.9 Install piping and ductwork which are to be insulated so that they have sufficient clearance to permit insulation and finish to be applied continuously and unbroken around pipe or duct, except for ductwork at fire barriers, in which case insulation will be terminated at each side of the duct fire damper.
 - 3.1.10 Inspect surfaces and structure prepared by other trades before performing work. Verify surfaces or structure to receive work has no defects or discrepancies which could result in poor application or cause latent defects in installation and workmanship. Report defects in writing. Installation of work will constitute acceptance of such surfaces as being satisfactory.
 - 3.1.11 Any ferrous piping that exhibits in excess of 5% surface rust, either inside or outside or both, is to be wire brush cleaned to bare metal and coated with suitable primer. Steel pipe, fittings and accessories are to be free of corrosion and dirt when work is complete or prior to being concealed from view. Where dirt is evident, clean piping prior to being concealed.
 - 3.1.12 For factory applied finishes, repaint or refinish surfaces damaged during shipment and installation. Quality of repair work is to match original finish. This requirement also applies to galvanized finishes.
 - 3.1.13 Where mechanical work is located in high humidity areas where ferrous metal products will be subject to corrosion and protection for such products is not specified, provide finishes on products to protect against corrosion or provide products which will not corrode in the environment, i.e. aluminium ductwork, copper or stainless steel pipe, etc.
 - 3.1.14 Provide screwed unions or flanges in piping connections to equipment and in regular intervals in long (in excess of 12 m (40')) piping runs to permit removal of sections of piping.
 - 3.1.15 Unless otherwise specified and except where space limitations do not permit, piping elbows are to be long radius. Eccentric reducers are to be installed with straight side at top of piping.

3.2 PIPE JOINT REQUIREMENTS

- 3.2.1 Do not make pipe joints in walls or slabs.
 - 3.2.2 Ream piping ends prior to making joints.
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- 3.2.3 Properly cut threads in screwed steel piping and coat male threads only with Teflon tape or paste, or an equivalent thread lubricant. After pipe has been screwed into fitting, valve, union, or piping accessory, not more than 2 pipe threads are to remain exposed.
- 3.2.4 Site bevel steel pipe to be welded or supply mill bevelled pipe. Remove scale and oxide from bevels and leave smooth and clean. Use factory made welding tees or welding outlet fittings for piping branches off mains. Do not use shop or site fabricated fittings unless written approval has been obtained.
- 3.2.5 Welded joints are to be made by CWB certified licensed journeyman welders qualified in accordance with CSA B51, Boiler Pressure Vessel and Pressure Piping Code, and who are in possession of a proper certificate of qualification for each procedure to be performed. Each weld is to be identified with the welder's identification symbol, and welds are not to be concealed until they have been inspected and approved. Electrodes are to be in accordance with CSA W48 Series, Electrodes, and requirements of CAN/CSA W117.2, Safety in Welding, Cutting and Allied Processes are to be followed.
- 3.2.6 Unless otherwise specified, make flanged joints with Garlock 5500 or equivalent gasket materials to suit the application, and bolts and nuts. Bolts are not to be longer than length necessary to screw nut up flush to the end of bolt. Bolts used for flanged connections in piping with a working pressure of 690 kPa (100 psi) and greater are to be ASTM A-193 Grade B-7, with heavy hexagon nuts to ASTM A-194 CL-2H. Provide suitable washers between each bolt head and flange and between each nut and flange.
- 3.2.7 A random check of bolted flanged connections will be made to verify flanged connections are properly mated with no shear force acting on bolts. Supply labour to disconnect and reconnect selected flanged joints. If improperly mated joints are found, remove and reinstall affected piping so flanges mate properly. If improperly mated joints are found, additional joints will be checked, and you will be responsible for the repair of any other improper joints discovered.
- 3.2.8 Unless otherwise specified make soldered joints in copper piping using flux suitable for and compatible with type of solder being used. Clean the outside of pipe end and inside of fitting, valve, or similar accessory prior to soldering.
- 3.2.9 Install mechanical joint fittings and couplings in accordance with manufacturer's instructions.
- 3.2.10 Grooves are to be rolled. Make arrangements with coupling and fitting manufacturer for shop and/or site instructions and demonstrations as required, and adhere to manufacturer's instructions with respect to pipe grooving, support, type of gasket required, anchoring and guiding the grooved piping system.
- 3.2.11 If pressure crimped couplings and fittings are used, ensure gaskets are fully compatible with piping fluid, and valves and piping accessories are suitable. Use only fitting manufacturer supplied crimping equipment. Comply with manufacturer's latest published specification, instructions, and recommendations with respect to pipe, coupling, and fitting preparation and installation, and support, anchoring and guiding of the piping system.
- 3.2.12 Solvent weld PVC piping in 2 parts, primer stage and cementing stage, in accordance with manufacturer's recommendations, ASTM D2855, and CSA requirements.
- 3.2.13 Install PVC piping with gasketed joints in accordance with manufacturer's current published specifications, instructions and recommendations, and CSA requirements.

3.3 DUCT OPENINGS

- 3.3.1 Duct openings, air inlet and outlet openings, fire damper and similar openings will be provided in new poured concrete work, masonry, drywall and other building surfaces by trade responsible for particular construction in which opening is required.
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- 3.3.2 Size openings for fire dampers to suit damper arrangement with folding blade out of air stream.
- 3.3.3 For duct openings except where fire dampers are required, pack and seal space between duct or duct insulation and duct opening as specified above for pipe openings in non-fire rated construction.

3.4 SLEEVE AND FORMED OPENING LOCATION DRAWINGS

- 3.4.1 Prepare and submit for review, drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.
- 3.4.2 Such drawings are to be completely and accurately dimensioned and relate sleeve, recesses, and formed openings to suitable grid lines and elevation datum, and are to take into account structural items such as grade beams, column caps, and column drop slabs.
- 3.4.3 Begin to prepare such drawings immediately upon notification of acceptance of bid and award of Contract.

3.5 INSTALLATION OF PIPE ESCUTCHEON PLATES

- 3.5.1 Provide escutcheon plates suitably secured over exposed piping passing through finished building surfaces. A finished building surface is any surface with a factory finish or that receives a site applied finish.
- 3.5.2 Install plates so they are tight against building surface concerned, completely covering pipe sleeves and/or openings, except where waterproof sleeves extend above floors, in which case fit plate tightly around sleeve.

3.6 SUPPLY OF ACCESS DOORS

- 3.6.1 Supply access doors to give access to mechanical work which may need maintenance or repair but which is concealed in inaccessible construction, except as otherwise specified herein or on drawings.
- 3.6.2 Before commencing installation of mechanical work, coordinate with other trades and prepare on a set of reflected ceiling plans and wall elevations, complete layouts of access doors. Submit these layouts for Consultant's review and show exact sizes and locations of such access doors. Locate and arrange mechanical work to suit.
- 3.6.3 Access doors will be installed by trade responsible for particular type of construction in which doors are required. Supply access doors to trade installing same at proper time.
- 3.6.4 Wherever possible, access doors to be of a standard size for each application. Confirm exact dimensions and minimum size restrictions with the Consultant prior to ordering.
- 3.6.5 Group piping and ductwork to ensure minimum number of access doors is required.
- 3.6.6 Coordinate with Electrical Contractor and General Trades Contractor to ensure access doors on project are provided by a single manufacturer, installed as part of work of General Trades Contractor and work involving both mechanical and electrical services should, where possible, be accessible from common access door. Coordinate work to ensure common location access doors are not supplied by both Mechanical Divisions and Electrical Divisions.

3.7 INSTALLATION OF VALVES

- 3.7.1 Generally, valve locations are indicated or specified on drawings or specified in Sections of the Specification where valves are specified, however, regardless of locations shown or specified, following requirements apply:
 - 3.7.1.1 provide shut-off valves to isolate systems, at base of vertical risers, in branch take-offs at mains and risers on floors, to isolate equipment, to permit work phasing as required, and wherever else required for proper system operation and maintenance;

- 3.7.1.2 install shut-off valves with handles upright or horizontal, not inverted, and located for easy access;
- 3.7.1.3 unless otherwise specified, provide a check valve in discharge piping of each pump;
- 3.7.1.4 valve sizes are to be same as connecting pipe size;
- 3.7.1.5 valves are to be permanently identified with size, manufacturer's name, valve model or figure number and pressure rating, and wherever possible, valves are to be product of same manufacturer;
- 3.7.1.6 for valves in insulated piping, design of valve stem, handle and operating mechanism is to be such that insulation does not have to be cut or altered in any manner to permit valve operation.

3.8 FINISH PAINTING OF MECHANICAL WORK

- 3.8.1 Finish paint exposed mechanical work as specified and/or scheduled in accordance with requirements of Division 09.
- 3.8.2 Touch-up paint damaged factory applied finishes on mechanical work products.

3.9 PIPE LEAKAGE TESTING

- 3.9.1 Before piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test piping for leakage.
 - 3.9.2 Tests are to be witnessed by the Consultant and/or Owner's representative, and, where required, representatives of governing authorities. Give ample notice of tests in writing and verify attendance. Have completed test report sheets dated and signed by those present to confirm proper test results.
 - 3.9.3 When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.
 - 3.9.4 Gravity Drainage and Vent Piping
 - 3.9.4.1 Test piping in accordance with local governing building code.
 - 3.9.4.2 After fixtures and fittings are set and pipes are connected to building drain or drains, turn on water into pipe, fixtures, fittings and traps in order to detect any imperfect material or workmanship. Perform a smoke test if required by local governing authorities.
 - 3.9.5 Pumped Drainage Piping
 - 3.9.5.1 Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for a minimum of 2 hours.
 - 3.9.6 Domestic Water Piping
 - 3.9.6.1 Test piping with cold water at a pressure of 1-½ times normal working pressure and maintain pressure for a minimum of 2 hours.
 - 3.9.7 Sprinkler System Piping
 - 3.9.7.1 Test system piping in accordance with requirements of NFPA No. 13, "Installation of Sprinkler Systems", and in accordance with any additional requirements of governing authorities.
 - 3.9.8 Standpipe System Piping
 - 3.9.8.1 Test system piping in accordance with requirements of NFPA No. 14, "Standpipe and Hose Systems", and in accordance with any additional requirements of governing authorities.
 - 3.9.9 CO2 Fire Extinguishing System Piping
 - 3.9.9.1 Test system piping in accordance with requirements of NFPA No. 12, "Standard on Carbon Dioxide Extinguishing Systems", and in accordance with any additional requirements of governing authorities.
 - 3.9.10 Clean Agent Fire Extinguishing System Piping
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- 3.9.10.1 Test system piping in accordance with requirements of NFPA No. 2001, "Standard on Clean Agent Extinguishing Systems", and in accordance with any additional requirements of governing authorities.
 - 3.9.11 Heat Transfer (HVAC) System Piping
 - 3.9.11.1 Test piping with cold water at a pressure of 1035 kPa (150 psi) for a minimum of 2 hours.
 - 3.9.12 Steam and Condensate Piping
 - 3.9.12.1 Test piping with cold water for a minimum of 2 hours at following pressures:
 - (1) 0 kPa to 105 kPa (0 psi to 15 psi) low pressure piping – 690 kPa (100 psi);
 - (2) 110 kPa to 690 kPa (16 psi to 100 psi) medium pressure piping – 1035 kPa (150 psi);
 - (3) greater than 690 kPa (100 psi) high pressure piping – 1380 kPa (200 psi).
 - 3.9.13 Natural Gas Piping
 - 3.9.13.1 Test piping in accordance with requirements of CAN/CSA B149.1 and any additional requirements of local governing authorities.
 - 3.9.13.2 After completion of the verification test, locate required tag stating results of the verification test at the point of entry of gas main into building, affixed to the pipe in a secure manner.
 - 3.9.13.3 Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.
 - 3.9.14 Propane Gas Piping
 - 3.9.14.1 Test piping in accordance with requirements of CAN/CSA B149.2 and any additional requirements of local governing authorities.
 - 3.9.14.2 After completion of the verification test, locate required tag stating results of the verification test at the point of entry of gas main into building, affixed to the pipe in a secure manner.
 - 3.9.14.3 Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.
 - 3.9.15 Compressed Air Piping
 - 3.9.15.1 Test piping with dry compressed air or nitrogen at 690 kPa (100 psi) for a minimum of 2 hours.
 - 3.9.15.2 Test piping joints with a water-soap solution while piping is under pressure to detect leaks.
 - 3.9.16 Fuel Oil Piping
 - 3.9.16.1 Test piping (not tanks) with dry compressed air or nitrogen for a minimum period of 2 hours at 1035 kPa (150 psi).
 - 3.9.16.2 Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.
 - 3.9.17 Gasoline Piping
 - 3.9.17.1 Test piping (not tanks) with dry compressed air or nitrogen for a minimum period of 2 hours at 1035 kPa (150 psi) in accordance with TSSA requirements.
 - 3.9.17.2 Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.
 - 3.9.18 Refrigerant Piping
 - 3.9.18.1 Test refrigerant piping for leakage and dehydrate in accordance with requirements of Chapter 18 of ASHRAE Handbook - Fundamentals.
 - 3.9.19 Control Air Piping and Tubing
 - 3.9.19.1 Test control air piping and tubing with dry compressed air or nitrogen before concealing and again before connection of instruments.
 - 3.9.19.2 Rough-in test pressure is to be 345 kPa (50 psi) maintained over 24 hours with a pressure drop not to exceed 35 kPa (5 psi).
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- 3.9.19.3 Test joints for leaks with a soap solution.
- 3.9.19.4 Finish test is to be 205 kPa (30 psi) with a permissible loss of 7 kPa (1 psi) over a 4 hour period. Prior to connecting instruments, blow systems clean and dry, and test component connections for leaks with a water/soap solution.
- 3.9.20 Pure Water Piping
 - 3.9.20.1 When piping has been properly flushed and cleaned, test at 690 kPa (100 psi) for 2 hours with only distilled water or filtered dry compressed air. If distilled water is used, drain system when testing is complete.
- 3.9.21 Following requirements apply to all testing:
 - 3.9.21.1 ensure piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing;
 - 3.9.21.2 temporarily remove or valve off piping system specialties or equipment which may be damaged by test pressures prior to pressure testing systems, and flush piping to remove foreign matter;
 - 3.9.21.3 when testing is carried out below highest level of the particular system, increase test pressure by the hydrostatic head of 7 kPa (1 psi) for every 600 mm (24") below the high point;
 - 3.9.21.4 include for temporary piping connections required to properly complete tests;
 - 3.9.21.5 piping under test pressure is to have zero pressure drop for length of test period;
 - 3.9.21.6 tighten leaks found during tests while piping is under pressure. If this is impossible, remove and refit piping and reapply test until satisfactory results are obtained;
 - 3.9.21.7 where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions;
 - 3.9.21.8 tests are to be done in reasonably sized sections so as to minimize number of tests required;
 - 3.9.21.9 in addition to leakage tests specified above, demonstrate proper flow throughout systems including mains, connections and equipment, as well as proper venting and drainage, and include for any necessary system adjustments to achieve proper conditions.

3.10 INTERRUPTION TO AND SHUT-DOWN OF MECHANICAL SERVICES AND SYSTEMS

- 3.10.1 Coordinate shut-down and interruption to existing mechanical systems with Owner. Generally, shut-downs may be performed only between the hours of 12:00 midnight Friday until 6:00 a.m. Monday morning, unless otherwise specified in Division 01. Include for costs of premium time to perform work during nights, weekends or other times outside of normal working hours, which may be necessary to comply with stipulations specified herein this Article. Services for operation of existing non-renovated areas of building are to be maintained.
- 3.10.2 Upon award of a Contract, submit a list of anticipated shut-down times and their maximum duration.
- 3.10.3 Prior to each shut-down or interruption, inform Owner and the Consultant in writing 5 working days in advance of proposed shut-down or interruption and obtain written consent to proceed. Do not shut-down or interrupt any system or service without such written consent. Shutdowns of some essential services may require additional advance notification time.
- 3.10.4 Perform work associated with shut-downs and interruptions as continuous operations to minimize shut-down time and to reinstate systems as soon as possible, and, prior to any shut-down, ensure materials and labour required to complete the work for which shut-down is required are available at site.

- 3.10.5 Pipe freezing shall be used to connect new piping to existing piping. Alternative methods may be proposed, if site conditions are evaluated and permit, and are approved by the Consultant.
- 3.10.6 Where existing isolation valves do not hold, pipe freezing shall be used to connect new piping to existing piping.

3.11 MECHANICAL SERVICE REQUIREMENTS FOR FLOATING FLOOR SLABS

- 3.11.1 Where mechanical services are required to be installed in or through a vibration isolated floating slab, install such services so as not to transmit any vibration to base slab on which floating floor slab is placed.
- 3.11.2 Wherever possible, arrange mechanical work to avoid penetrating a floating floor slab.

3.12 EXCAVATION AND BACKFILL WORK

- 3.12.1 Unless otherwise specified in Division 31, provide all excavation and backfill associated with the mechanical scope of work.
 - 3.12.2 Before commencement of excavation for work, determine in consultation with Consultant, Owner, Municipality and utilities, presence, if any, of existing underground services at site. Engage local utilities to locate and mark out such services. Ensure trades concerned are aware of their presence.
 - 3.12.3 Be responsible for any damage done to underground services caused by neglect to determine and mark out location of such services prior to excavation work commences.
 - 3.12.4 Where Work falls under jurisdiction of local governing utility, confirm requirements and comply with utility requirements.
 - 3.12.5 Unless otherwise specified in Division 31, provide excavation, backfill and related work required for mechanical work. Obtain a copy of soil test report if available from the Consultant. Depth of excavations must accommodate local governing requirements and local standard practices to compensate for local frost levels of Place of the Work.
 - 3.12.6 Inverts and locations of existing site services may have been site surveyed and approximate location may be shown on drawings. Confirm inverts and locations are correct, prior to commencing excavation and contact Utilities to accurately locate their services. Where discrepancies are found, immediately inform Consultant, and await a direction. Grade bottom of trench excavations as required.
 - 3.12.7 In firm, undisturbed soil, lay pipes directly on soil, unless otherwise directed.
 - 3.12.8 Before backfilling, arrange for inspection of work by the Consultant. Do not backfill work unless reviewed with the Consultant. Failure to do so prior to backfilling will require re-excavating work and re-backfill at no additional cost to Owner.
 - 3.12.9 Unless otherwise specified, backfill trenches within building with clean sharp sand in individual layers of maximum 150 mm (6") thickness compacted to a density of 100% Standard Proctor. Hand compact first layers up to a compacted level of minimum 300 mm (12") above top of pipe. Hand or machine compact the balance up to grade.
 - 3.12.10 Unless otherwise specified, backfill trenches outside the building (not under roads, parking lots or traffic areas), up to a compacted level of 450 mm (18") thick above the pipe, hand compacted to a density of 95% Standard Proctor, using granular "A" gravel. Backfill the balance in 150 mm (6") layers with approved excavated material, compacted to 95% Standard Proctor density.
 - 3.12.11 Unless otherwise specified, backfill trenches outside building under roads, parking lots or traffic areas with crushed stone or granular "A" gravel in layers not exceeding 150 mm (6") thickness, compacted to 100% Standard Proctor density up to grade level.
 - 3.12.12 Provide minimum 1.37 m (4.5') of cover for underground piping subject to freezing and located outside building.
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- 3.12.13 Provide minimum 450 mm (18") of cover for underground piping subject to freezing and located inside building.
- 3.12.14 After first lift of backfill has been compacted, mark entire path of pipe using continuous 75 mm (3") wide detectable identified marking tape equal to SMS Ltd. D-UGMT.
- 3.12.15 Unless otherwise directed in Division 31, store and dispose of excavated materials as follows:
 - 3.12.15.1 during progress of contract, place material as directed in such a manner to minimize damage or disfigurement of ground and which in no way impedes progress of work;
 - 3.12.15.2 separately place surplus topsoil and subsoil as directed; leave site clean and unencumbered.
- 3.12.16 Perform pumping as required to keep excavations free of water.
- 3.12.17 Engage services of independent soils testing agency to test final backfill compaction density of each backfilled location. Compact backfill to satisfaction of testing agency and in accordance with Specification. Submit a copy of testing agency's report to the Consultant for review.
- 3.12.18 Fill depressions to correct grade level with appropriate material, after an adequate period has passed to reveal any settlement. Use maximum possible compaction. Pay costs required to make good damages caused by settlement.
- 3.12.19 Coordinate requirements for final surface toppings (concrete, asphalt, pavers, grass sod, etc.) with General Contractor.

3.13 CUTTING, PATCHING AND CORE DRILLING

- 3.13.1 Unless otherwise provided by General Trades, perform cutting, patching, and core drilling of existing building required for installation of mechanical work. Perform cutting in a neat and true fashion, with proper tools and equipment to Consultant's approval. Patching is to exactly match existing finishes and be performed by tradesmen skilled in particular trade or application. Work is subject to review and acceptance by the Consultant.
 - 3.13.2 Criteria for cutting holes for additional services:
 - 3.13.2.1 cut holes through slabs only; no holes to be cut through beams;
 - 3.13.2.2 cut holes 150 mm (6") diameter or smaller only; obtain approval from Structural Consultant for larger holes;
 - 3.13.2.3 keep at least 100 mm (4") clear from beam faces;
 - 3.13.2.4 space at least 3 hole diameters on centre;
 - 3.13.2.5 for holes that are required closer than 25% of slab span from supporting beam face, use cover meter above slab to clear slab top bars;
 - 3.13.2.6 for holes that are required within 50% of slab span, use cover meter underside of slab to clear slab bottom bars;
 - 3.13.2.7 submit sleeving drawings indicating holes and their locations for Structural Consultant's review.
 - 3.13.3 Do not cut or drill any existing work without approval from Owner and Consultant. Be responsible for damage done to building and services caused by cutting or drilling.
 - 3.13.4 Where pipes pass through existing construction, core drill an opening. Size openings to leave 12 mm (½") clearance around pipes or pipe insulation.
 - 3.13.5 Prior to drilling or cutting an opening, determine, in consultation with Consultant and Owner, and by use of non-destructive radar scan (magnetic scan) of slab or wall, presence of any existing services and reinforcement bars concealed behind building surface to be cut and locate openings to suit. Coring is not permitted through concrete beams or girders.
 - 3.13.6 Where drilling is required in waterproof slabs, size opening to permit snug and tight installation of a pipe sleeve sized to leave 12 mm (½") clearance around pipe or pipe
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insulation. Provide a pipe sleeve, constructed of Schedule 40 galvanized steel pipe with a flange at one end and of a length to extend 100 mm (4") above slab, in opening. Secure flange to the underside of slab and caulk void between sleeve and slab opening with proper non-hardening silicone base caulking compound to produce a water-tight installation.

- 3.13.7 Firestop and seal openings in fire rated construction. Do not leave openings open overnight unless approved by Owner and Consultant.

3.14 PACKING AND SEALING CORE DRILLED PIPE OPENINGS

- 3.14.1 Pack and seal void between pipe opening and pipe or pipe insulation for length of opening as follows:
- 3.14.1.1 non-fire rated interior construction – pack with mineral wool and seal both ends of opening with non-hardening silicone base caulking compound to produce a water-tight seal;
 - 3.14.1.2 exterior walls above grade – pack with mineral wool and seal both ends of sleeves water-tight with non-hardening silicone base caulking compound unless mechanical type seals have been specified;
 - 3.14.1.3 exterior walls below grade (and any other wall where water leakage may be a problem) – seal with link type mechanical seals as specified.

3.15 FLASHING FOR MECHANICAL WORK PENETRATING ROOF

- 3.15.1 Unless otherwise specified in Division 07, perform required flashing work, including counter-flashing, for mechanical work penetrating and/or set in roof.
- 3.15.2 Perform flashing work in accordance with requirements of drawing details and/or requirements specified in Division 07.

3.16 CLEANING MECHANICAL WORK

- 3.16.1 Refer to cleaning requirements specified in Division 01.
- 3.16.2 Clean mechanical work prior to application for Substantial Performance of the Work.
- 3.16.3 Include for vacuum cleaning interior of air handling units and ductwork systems.

3.17 CONNECTIONS TO OTHER EQUIPMENT

- 3.17.1 Carefully examine Contract Documents during bidding period and include for mechanical work piping and/or ductwork connections to equipment requiring such connections.

3.18 SEISMIC RESTRAINT ANCHOR POINTS FOR EQUIPMENT

- 3.18.1 Where mechanical equipment requires seismic restraint, it is to be complete with manufacturer designed and rated seismic restraint anchor points and attachments, certified by equipment manufacturers, so equipment may be bolted down or restrained in the field.
- 3.18.2 Equipment to be restrained must be designed such that the strength and anchorage of its internal components exceed force level; used to restrain and anchor the equipment to the supporting structure.

3.19 INSTALLATION OF FLEXIBLE CONNECTORS

- 3.19.1 Provide flexible connectors in piping connections to seismically restrained equipment, where applicable, and wherever else shown.
- 3.19.2 Provide flexible connectors in piping connections to vibration isolated equipment.
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3.20 FAN NOISE LEVELS

- 3.20.1 Submit sound power levels with fan shop drawings/product data, with levels measured to AMCA 300 and calculated to AMCA 301.

3.21 EQUIPMENT AND SYSTEM MANUFACTURER'S CERTIFICATION

- 3.21.1 When equipment/system installation is complete, but prior to start-up procedures, arrange and pay for equipment/system manufacturer's authorized representative to visit site to examine installation, and after any required corrective measures have been made, to certify in writing to the Consultant that equipment/system installation is complete and in accordance with equipment/system manufacturer's instructions.

3.22 SYSTEM STARTUP

- 3.22.1 When installation of equipment/systems is complete but prior to commissioning, perform start-up for equipment/systems as specified in mechanical work Sections in accordance with following requirements:
 - 3.22.1.1 submit a copy of each equipment/system manufacturer's start-up report sheet to the Consultant for review, and incorporate any comments made by the Consultant;
 - 3.22.1.2 under direct on-site supervision and involvement of equipment/system manufacturer's representative, start-up equipment/systems, make any required adjustments, document procedures, leave equipment/systems in proper operating condition, and submit to the Consultant complete set of start-up documentation sheets signed by manufacturer/supplier and Contractor;
 - 3.22.1.3 commission interconnected life safety systems in accordance with CAN/ULC-S1001-11 and provide written report for Consultant's review.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 This Section specifies requirements that are common to Mechanical Divisions work Sections and it is a supplement to each Section and is to be read accordingly. Where requirements of this Section contradict requirements of Division 00 or Division 01, conditions of Division 00 or Division 01 to take precedence.
- 1.1.2 Be responsible for advising product vendors of requirements of this Section.

1.2 RELATED REQUIREMENTS

- 1.2.1 Division 00 and Division 01 apply to and are a part of this Section.

1.3 DEFINITIONS

- 1.3.1 "concealed" – means hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.
 - 1.3.2 "exposed" – means work normally visible, including work in equipment rooms, service tunnels, and similar spaces.
 - 1.3.3 "finished" - means when in description of any area or part of an area or a product which receives a finish such as paint, or in case of a product may be factory finished.
 - 1.3.4 "provision" or "provide" (and tenses of "provide") – means supply and install complete.
 - 1.3.5 "install" (and tenses of "install") – means secure in position, connect complete, test, adjust, verify, and certify.
 - 1.3.6 "supply" – means to procure, arrange for delivery to site, inspect, accept delivery and administer supply of products; distribute to areas; and include manufacturer's supply of any special materials, standard on site testing, initial start-up, programming, basic commissioning, warranties and manufacturers' assistance to Contractor.
 - 1.3.7 "delete" or "remove" (and tenses of "delete" or "remove") – means to disconnect, make safe, and remove obsolete materials; patch and repair/finish surfaces to match adjoining similar construction; include for associated re-programming of systems and/or change of documentation identifications to suit deletions, and properly dispose of deleted products off site unless otherwise instructed by Owner and reviewed with the Consultant.
 - 1.3.8 "BAS" – means building automation system; "BMS" – means building management system; "FMS" – means facility management system; and "DDC" means direct digital controls; references to "BAS", "BMS", "FMS" and "DDC" generally mean same.
 - 1.3.9 "governing authority" and/or "authority having jurisdiction" and/or "regulatory authority" and/or "Municipal authority" – means government departments, agencies, standards, rules and regulations that apply to and govern work and to which work must adhere.
 - 1.3.10 "OSHA" and "OHSA" – stands for Occupational Safety and Health Administration and Occupational Health and Safety Act, and wherever either one is used, they are to be read to mean local governing occupational health and safety regulations that apply to and govern work and to which work must adhere, regardless if Project falls within either authority's jurisdiction.
 - 1.3.11 "Mechanical Divisions" – refers to Division 20, Division 21, Division 22, Division 23, Division 25, and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Mechanical Contractor, unless otherwise noted.
 - 1.3.12 "Electrical Divisions" – refers to Division 26, Division 27, Division 28, and other Divisions as specifically noted, and which work as defined in Specifications and/or on drawings is responsibility of Electrical Contractor, unless otherwise noted.
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- 1.3.13 "Consultant" – means person, firm or corporation identified as such in Agreement or Documents, and is licensed to practice in Place of the Work, and has been appointed by Owner to act for Owner in a professional capacity in relation to the Work.
- 1.3.14 Wherever words "indicated", "shown", "noted", "listed", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean product referred to is "indicated", "shown", "listed", or "noted" on Contract Documents.
- 1.3.15 Wherever words "reviewed", "satisfactory", "as directed", "submit", or similar words or phrases are used in Contract Documents they are understood, unless otherwise defined, to mean that work or product referred to is "reviewed by", "to the satisfaction of", "submitted to", etc., Consultant.

1.4 DOCUMENTS

- 1.4.1 Documents for bidding include but are not limited to issued Drawings, Specifications and Addenda.
 - 1.4.2 Specification is arranged in accordance with CSI/CSC 49 Divisions of MasterFormat.
 - 1.4.3 Drawings and Specifications are portions of Contract Documents and identify labour, products and services necessary for performance of work and form a basis for determining pricing. They are intended to be cooperative. Perform work that is shown, specified, or reasonably implied on the drawings but not mentioned in Specification, or vice-versa, as though fully covered by both.
 - 1.4.4 Review Drawings and Specifications in conjunction with documents of other Divisions and, where applicable, Code Consultant's report.
 - 1.4.5 Unless otherwise specifically noted in Specifications and/or on Drawings, Sections of Mechanical Divisions are not intended to delegate functions nor to delegate work and supply of materials to any specific trade, but rather to generally designate a basic unit of work, and Sections are to be read as a whole.
 - 1.4.6 Drawings are performance drawings, diagrammatic, and show approximate locations of equipment and connecting services. Any information regarding accurate measurement of building is to be taken on site. Do not scale Drawings, and do not use Drawings for prefabrication work.
 - 1.4.7 Drawings are intended to convey the scope of work and do not show architectural and structural details. Provide, at your cost, offsets, fittings, transformations and similar products required as a result of obstructions and other architectural and/or structural details but not shown on Drawings.
 - 1.4.8 Locations of equipment and materials shown may be altered, when reviewed by the Consultant, to meet requirements of equipment and/or materials, other equipment or systems being installed, and of building, all at no additional cost to Contract.
 - 1.4.9 Specification does not generally indicate specific number of items or amounts of material required. Specification is intended to provide product data and installation requirements. Refer to schedules, Drawings (layouts, riser diagrams, schematics, details) and Specification to provide correct quantities. Singular may be read as plural and vice versa.
 - 1.4.10 Starter/motor control centre (MCC)/variable frequency drive (VFD) schedule drawings are both mechanical and electrical, and apply to work of Mechanical Divisions and Electrical Divisions. Be responsible for reviewing starter, MCC, VFD, and motor specification requirements prior to Bid submission. Confirm and coordinate exact scope of work and responsibility of work between Mechanical Divisions and Electrical Divisions.
 - 1.4.11 Drawings and Specifications have been prepared solely for use by party with whom Consultant has entered into a contract and there are no representations of any kind made by the Consultant to any other party.
 - 1.4.12 In the case of discrepancies between the drawings and specifications, documents will govern in order specified in "General Conditions", however, when scale and date of
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drawings are same, or where discrepancy exists within specification, most costly arrangement will take precedence.

1.5 METRIC AND IMPERIAL MEASUREMENTS

- 1.5.1 Generally, both metric and imperial units of measurement are given in Sections of Specification governed by this section. Measurement conversions may be generally "soft" and rounded off. Confirm exact measurements based on application. Where measurements are related to installation and onsite applications, confirm issued document measurements with applicable local code requirements, and/or as applicable, make accurate measurements onsite. Where significant discrepancies are found, immediately notify Consultant for direction.

1.6 EXAMINATION OF DOCUMENTS AND SITE

- 1.6.1 Carefully examine Documents and visit site to determine and review existing site conditions that will or may affect work, and include for such conditions in Bid Price.
- 1.6.2 Report to Consultant, prior to Bid Submittal, any existing site condition that will or may affect performance of work as per Documents. Failure to do so will not be grounds for additional costs.
- 1.6.3 Upon finding discrepancies in, or omissions from Documents, or having doubt as to their meaning or intent, immediately notify Consultant, in writing.

1.7 WORK STANDARDS

- 1.7.1 Where any code, regulation, bylaw, standard, contract form, manual, printed instruction, and installation and application instruction is quoted it means, unless otherwise specifically noted, latest published edition at time of submission of Bids adopted by and enforced by local governing authorities having jurisdiction. Include for compliance with revisions, bulletins, supplementary standards or amendments issued by local governing authorities.
- 1.7.2 Where regulatory codes, standards and regulations are at variance with Drawings and Specification, more stringent requirement will apply unless otherwise directed by Owner and reviewed with the Consultant.
- 1.7.3 Supplementary mandatory specification and requirements to be used in conjunction with project include but are not limited to following:
 - 1.7.3.1 Air-Conditioning, Heating and Refrigeration Institute (AHRI);
 - 1.7.3.2 Air Movement and Control Association (AMCA);
 - 1.7.3.3 American Iron and Steel Institute (AISI);
 - 1.7.3.4 American National Standards Institute (ANSI);
 - 1.7.3.5 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., (ASHRAE);
 - 1.7.3.6 American Society of Mechanical Engineers (ASME);
 - 1.7.3.7 American Society of Testing and Materials (ASTM);
 - 1.7.3.8 American Water Works Association (AWWA);
 - 1.7.3.9 Associated Air Balance Council (AABC);
 - 1.7.3.10 Building Industry Consulting Services, International (BICSI);
 - 1.7.3.11 Canadian Gas Association (CGA);
 - 1.7.3.12 Canadian General Standards Board (CGSB);
 - 1.7.3.13 Canadian Standards Association (CSA);
 - 1.7.3.14 Electrical and Electronic Manufacturers Association of Canada (EEMAC);
 - 1.7.3.15 Electrical Safety Authority (ESA);
 - 1.7.3.16 Electronic Industries Association (EIA);
 - 1.7.3.17 Factory Mutual Systems (FM);
 - 1.7.3.18 Illuminating Engineering Society (IES);

- 1.7.3.19 Institute of Electrical and Electronic Engineers (IEEE);
 - 1.7.3.20 International Standards Organization (ISO);
 - 1.7.3.21 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS);
 - 1.7.3.22 National Building Code of Canada (NBC);
 - 1.7.3.23 National Electrical Manufacturers Association (NEMA);
 - 1.7.3.24 National Environmental Balancing Bureau (NEBB);
 - 1.7.3.25 National Fire Protection Association (NFPA);
 - 1.7.3.26 National Standards of Canada;
 - 1.7.3.27 NSF International;
 - 1.7.3.28 Occupational Health and Safety Act (OHSA);
 - 1.7.3.29 Ontario Building Code (OBC);
 - 1.7.3.30 Ontario Electrical Safety Code (OESC);
 - 1.7.3.31 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA);
 - 1.7.3.32 Technical Standards and Safety Authority (TSSA);
 - 1.7.3.33 Thermal Insulation Association of Canada (TIAC);
 - 1.7.3.34 Underwriters' Laboratories of Canada (ULC);
 - 1.7.3.35 Workplace Hazardous Materials Information System (WHMIS);
 - 1.7.3.36 Material Safety Data Sheets by product manufacturers;
 - 1.7.3.37 Local utility inspection permits;
 - 1.7.3.38 Codes, standards, and regulations of local governing authorities having jurisdiction;
 - 1.7.3.39 Additional codes and standards listed in Trade Sections;
 - 1.7.3.40 Owner's standards.
 - 1.7.4 Provide applicable requirements for barrier free access in accordance with latest edition of local governing building code.
 - 1.7.5 Where any governing Code, Regulation, or Standard requires preparation and submission of special details or drawings for review they are to be prepared and submitted to appropriate authorities. Be responsible for costs associated with these submittals.
 - 1.7.6 Unless otherwise specified, install equipment in accordance with equipment manufacturer's recommendations and instructions, and requirements of governing Codes, Standards, and Regulations. Governing Codes, Standards, and Regulations take precedence over manufacturer's instructions.
 - 1.7.7 Work is to be performed by journeyperson tradesmen who perform only work that their certificates permit, or by apprentice tradesmen under direct on site supervision of experienced journeyperson tradesman. Journeyperson to apprentice ratio is not to exceed ratio determined by the Board as stated in Ontario College of Trades and Apprenticeship Act or local equivalent governing body in Place of the Work.
 - 1.7.8 Journeyperson tradesmen are to have a copy of valid trade certificates available at site for review with the Consultant at any time.
 - 1.7.9 Experienced and qualified superintendent is to be on-site at times when work is being performed.
 - 1.7.10 Coordinate work inspection reviews and approvals with governing inspection department to ensure that construction schedule is not delayed. Be responsible for prompt notification of deficiencies to the Consultant and submission of reports and certificates to the Consultant.
 - 1.7.11 Properly protect equipment and materials on site from damage due to elements and work of trades, to satisfaction of Owner and reviewed with the Consultant. Equipment and materials are to be in new condition upon Substantial Performance of the Work.
 - 1.7.12 Mechanical piping system work, including equipment, must comply in all respects with requirements of local technical standards authorities and CSA B51, Boiler, Pressure
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Vessels and Pressure Piping Code. Where required, mechanical work products must bear a CRN number.

- 1.7.13 Electrical items associated with mechanical equipment are to be certified and bear stamp or seal of a recognized testing agency such as CSA, UL, ULC, ETL, etc., or bear a stamp to indicate special electrical utility approval.

1.8 PERMITS, CERTIFICATES, APPROVALS, AND FEES

- 1.8.1 Contact and confirm with local authorities having jurisdiction including utility providers, requirements for approvals from such authorities. Obtain and pay for permits, certificates, and approvals required to complete Work.
- 1.8.2 Be responsible for ensuring that authorities having jurisdiction which require on-site inspection of work, have ample notification to perform inspection, with sufficient lead time to correct deficiencies in a manner that will not impede schedule of completion of Work. If any defect, deficiency or non-compliant is found in work by inspection, be responsible for costs of such inspection, including any related expenses, making good and return to site, until work is passed by governing authorities.
- 1.8.3 Obtain and submit to Consultant, approval/inspection certificates issued by governing authorities to confirm that Work as installed is in accordance with rules and regulations of local governing authorities and are acceptable.
- 1.8.4 Include in each copy of operating and maintenance instruction manuals, copies of approvals and inspection certificates issued by regulatory authorities.

1.9 REQUIREMENTS FOR CONTRACTOR RETAINED ENGINEERS

- 1.9.1 Professional engineers retained to perform consulting services with regard to Project work, i.e. seismic engineer, fire protection engineer or structural engineer, are to be members in good standing with local Association of Professional Engineers, and are to carry and pay for errors and omissions professional liability insurance in compliance with requirements of governing authorities in Place of the Work.
- 1.9.2 Retained engineer's professional liability insurance is to protect Contractor's consultants and their respective servants, agents, and employees against any loss or damage resulting from professional services rendered by aforementioned consultants and their respective servants, agents, and employees in regards to the Work of this Contract.
- 1.9.3 Unless otherwise specified in Division 00 or Division 01, liability insurance requirements are as follows:
 - 1.9.3.1 coverage is to be a minimum of \$1,000,000.00 CDN inclusive of any one occurrence;
 - 1.9.3.2 insurance policy is not to be cancelled or changed in any way without insurer giving Owner minimum thirty days written notice;
 - 1.9.3.3 liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the Place of the Work;
 - 1.9.3.4 retained consultants are to ascertain that sub-consultants employed by them carry insurance in the form and limits specified above;
 - 1.9.3.5 evidence of the required liability insurance in such form as may be required is to be issued to Owner, Owner's Consultant, and Municipal Authorities as required prior to commencement of aforementioned consultant's services.

1.10 WORKPLACE SAFETY

- 1.10.1 Comply with requirements of Workplace Hazardous Materials Information System (WHMIS) regarding use, handling, storage, and disposal of hazardous materials. Submit WHMIS MSDS (Material Safety Data Sheets) for products where required, and maintain one copy at site in a visible and accessible location available to personnel.
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- 1.10.2 Comply with requirements of Occupational Health and Safety Act and other regulations pertaining to health and safety, including worker's compensation/insurance board and fall protection regulations. When working in confined spaces, comply with requirements of Occupational Health and Safety Act - Ontario Regulation 632, "Confined Spaces" and any other applicable Ministry of Labour requirements.
- 1.10.3 If at any time during course of work, hazardous materials other than those identified in Documents and pertaining to Project Scope of Work, are encountered, or suspected that were not identified as being present and which specific instructions in handling of such materials were not given, cease work in area in question and immediately notify Consultant. Comply with local governing regulations with regards to working in areas suspected of containing hazardous materials. Do not resume work in affected area without approval from Owner and reviewed with the Consultant.

1.11 PLANNING AND LAYOUT OF WORK

- 1.11.1 Base installation layout, design, terminations, and supply of accessories, on Contract Documents with specific coordination with reviewed shop drawings.
 - 1.11.2 Plan, coordinate, and establish exact locations and routing of services with affected trades prior to installation such that services clear each other as well as other obstructions. Generally, order of right of way for services to be as follows:
 - 1.11.2.1 piping requiring uniform pitch;
 - 1.11.2.2 piping 100 mm (4") dia. and larger;
 - 1.11.2.3 large ducts (main runs);
 - 1.11.2.4 cable tray and bus duct;
 - 1.11.2.5 conduit 100 mm (4") dia. and larger;
 - 1.11.2.6 piping less than 100 mm (4") dia.;
 - 1.11.2.7 smaller branch ductwork;
 - 1.11.2.8 conduit less than 100 mm (4") dia.
 - 1.11.3 Unless otherwise shown or specified, conceal work in finished areas, and conceal work in partially finished and/or unfinished areas to extent made possible by the area construction. Install services as high as possible to conserve headroom and/or ceiling space. Notify Consultant where headroom or ceiling space appears to be inadequate prior to installation of work.
 - 1.11.4 Do not use Contract Drawing measurements for prefabrication and layout of piping, sheet metal work and such other work. Locations and routing are to generally be in accordance with Contract Drawings, however, prepare layout drawings for such work. Use established bench marks for both horizontal and vertical measurements. Confirm inverts, coordinate with and make allowances for work of other trades. Accurately layout work, and be entirely responsible for work installed in accordance with layout drawings. Where any invert, grade, or size is at variance with Contract Drawings, notify Consultant prior to proceeding with work.
 - 1.11.5 Prepare plan and interference drawings (at a minimum drawing scale of 1:50 or 1/4"=1' 0") of work for coordination with each trade Contractor. Arrange for preparation of detailed section drawings of ceiling spaces of corridors and any other congested areas. Sections are to be cross referenced with plan drawings so that trades may make use of section drawings. Section drawings to indicate lateral and elevation dimensions of major services within ceiling space. Lateral dimensions are to be from grid lines and elevations from top of floor slab. Obtain from Consultant, engineering drawings for this use. Contractors' interference drawings are to be distributed among other Trade Contractors. Submit drawings to the Consultant for review. Failure of General Contractor to prepare and coordinate overall interface drawings of trades does not relieve respective Division Contractor of responsibility to ensure that work is properly planned and coordinated.
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- 1.11.6 Carry out alterations in arrangement of work that has been installed without proper coordination, study, and review, even if in accordance with Contract Documents, in order to conceal work behind finishes, or to allow installation of other work, without additional cost. In addition, make necessary alterations in other work required by such alterations, without additional cost.
- 1.11.7 Shut-off valves, balancing devices, air vents, equipment, and similar products, particularly such products located above suspended ceilings must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an accessible location at no additional cost.
- 1.11.8 Be responsible for making necessary changes, at no additional cost, to accommodate structural and building conditions that were missed due to lack of coordination.

1.12 SCHEDULING

- 1.12.1 Include for any and all scheduling, coordination, and construction phasing to suit project, specified in Division 01 and/or as indicated on the drawings. Review exact phasing requirements with Consultant prior to start of Work.
- 1.12.2 Project partial occupancy permits may be required throughout project. Provide for each partial permit, required local governing authority certificate and any other testing/verification certificates for systems.

1.13 COORDINATION

- 1.13.1 Review Contract Documents and coordinate work with work of each trade. Coordination requirements are to include but not be limited to following:
 - 1.13.1.1 requirements for openings, sleeves, inserts and other hardware necessary for installation of work;
 - 1.13.1.2 concrete work such as housekeeping pads, sumps, bases, etc., required for work, and including required dimensions, operating weight of equipment, location, etc.;
 - 1.13.1.3 depth and routing of excavation required for work, and requirements for bedding and backfill;
 - 1.13.1.4 wiring work required for equipment and systems but not specified to be done as part of mechanical work, including termination points, wiring type and size, and any other requirements.
- 1.13.2 Ensure materials and equipment are delivered to site at proper time and in such assemblies and sizes so as to enter into building and be moved into spaces where they are to be located without difficulty.
- 1.13.3 Wherever possible, coordinate equipment deliveries with manufacturers and/or suppliers so equipment is delivered to site when it is required, or so it can be stored within building, subject to available space as confirmed with Owner and reviewed with Owner, and protected from elements.
- 1.13.4 Ensure proper access and service clearances are maintained around equipment, and, where applicable, access space for future equipment removal or replacement is not impeded. Comply with code requirements with regards to access space provision around equipment. Remove and replace any equipment which does not meet this requirement.
- 1.13.5 Where work is to be integrated, or is to be installed in close proximity with work of other trades, coordinate work prior to and during installation.

1.14 PRODUCTS

- 1.14.1 Be responsible for ordering of products (equipment and materials) in a timely manner in order to meet project-scheduling timelines. Failure to order products to allow manufacturers sufficient production/delivery time to meet project-scheduling timelines is an unacceptable reason to request for other suppliers or substitutions.
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- 1.14.2 Provide Canadian manufactured products wherever possible or required and when quality and performance is obtainable at a competitive price. Products are to be supplied from manufacturer's authorized Canadian representative, unless otherwise noted. Unless otherwise specified, products are to be new and are to comply with applicable respective Canadian standards. References to UL listings of products to include requirements that products are to be also Underwriters Laboratories of Canada (ULC) listed for use in Canada. Products are to meet or exceed latest ANSI/ASHRAE/IES 90.1 standards, as applicable. Do not supply any products containing asbestos materials or PCB materials.
 - 1.14.3 Systems and equipment of this Project are to be "State of the Art" and be most recent and up to date series/version of product that is available at time of shop drawing review process. Products that have been stored or "on shelf" for an extended period of time will not be accepted. Software is to be of latest version available and be provided with updates available at time of shop drawing review process. Systems are to be designed such that its software is backwards compatible. Future upgrades are not to require any hardware replacements or additions to utilize latest software.
 - 1.14.4 Products scheduled and/or specified have been selected to establish a performance and quality standard, and, in some instances, a dimensional standard. In most cases, base specified manufacturers are stated for any product specified by manufacturer's name and model number. Where manufacturers are listed, first name listed is base specified company. Bid Price may be based on products supplied by any of manufacturers' base specified or named as acceptable for particular product. If manufacturers are not stated for a particular product, base Bid Price on product supplied by base specified manufacturer.
 - 1.14.5 Documents have been prepared based on product available at time of Bidding. If, after award of Contract, and if successful manufacturer can no longer supply a product that meets base specifications, notify Consultant immediately. Be responsible for obtaining other manufacturers product that complies with base specified performance and criteria and meets project timelines. Proposed products are subject to review and consideration by the Consultant and are considered as substitutions subject to a credit to Contract. In addition, if such products require modifications to room spaces, mechanical systems, electrical systems, etc., include required changes. Such changes are to be submitted in detail to the Consultant for review and consideration for acceptance. There will be no increase in Contract Price for revisions. Above conditions supplement and are not to supersede any specification conditions with regards to substitutions or failure to supply product as per issued documents.
 - 1.14.6 Listing of a product as "acceptable" does not imply automatic acceptance by the Consultant and/or Owner. It is responsibility of Contractor to ensure that any price quotations received and submittals made are for products that meet or exceed specifications included herein.
 - 1.14.7 If products supplied by a manufacturer named as acceptable are used in lieu of base specified manufacturer, be responsible for ensuring that they are equivalent in performance and operating characteristics (including energy consumption if applicable) to base specified products. It is understood that any additional costs (i.e. for larger starters, larger feeders, additional spaces, etc.), and changes to associated or adjacent work resulting from provision of product supplied by a manufacturer other than base specified manufacturer, is included in Bid Price. In addition, in equipment spaces where equipment named as acceptable is used in lieu of base specified equipment and dimensions of such equipment differs from base specified equipment, prepare, and submit for review accurately dimensioned layouts of rooms affected, identifying architectural and structural elements, systems and equipment to prove that equipment in room will fit properly meeting design intent. There will be no increase in Contract Price for revisions.
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- 1.14.8 In addition to manufacturer's products base specified or named as acceptable, other manufacturers of products may be proposed as substitutions to the Consultant for review and consideration for acceptance, listing in each case a corresponding credit for each substitution proposed. However, base Bid Price on products base specified or named as acceptable. Certify in writing to the Consultant that proposed substitution meets space, power, design, energy consumption, and other requirements of base specified or acceptable product. It is understood that there will be no increase in Contract Price by reason of any changes to associated equipment, mechanically, electrically, structurally, or architecturally, required by acceptance of proposed substitution. Consultant has sole discretion in accepting any such proposed substitution of product. Indicate any proposed substitutions in areas provided on Bid Form. Do not order such products until they are accepted in writing by the Consultant.
- 1.14.9 Where products are listed as "or approved equal", certify in writing that product to be used in lieu of base specified product, at least meets space, power, design, energy consumption, and other requirements of base specified product and is equivalent or better than base specified product. When requested by the Consultant, provide full design detail drawings and specifications of proposed products. Acceptance of these "or approved equal" products is at sole discretion of the Consultant. It is understood that there will be no increase in Contract Price by reason of any changes to associated equipment, mechanically, electrically, structurally, or architecturally, required by acceptance of approved equal product. There must be no increase in Contract price due to Consultant's rejection of proposed equivalent product.
- 1.14.10 Whenever use of product other than base specified product is being supplied, ensure corresponding certifications and product information (detailed catalogue and engineering data, fabrication information and performance characteristics) are submitted to the Consultant for review. Failure of submission of these documents to the Consultant in a timely manner to allow for review will result in base specified product to be supplied at Consultant's discretion, at no additional cost to Contract.
- 1.14.11 Products supplied by a manufacturer/supplier other than a manufacturer listed as acceptable may be considered for acceptance by the Consultant if requested in writing with full product documentation submitted, a minimum of 10 working days prior to Bid closing date.
- 1.14.12 Any proposed changes initiated by Contractor after award of Contract may be considered by the Consultant at the Consultant's discretion, with any additional costs for such changes if accepted by Owner and reviewed with the Consultant, and costs for review, to be borne by Contractor.
- 1.14.13 Whenever use of product other than based specified products or named as acceptable is being supplied, time for process of submission of other products and Consultant's review of products will not alter contract time or delay work schedule.

1.15 SHOP DRAWINGS

- 1.15.1 At start-up meeting, review with the Consultant products to be included in shop drawing submission. Prepare and submit list of products to the Consultant for review.
- 1.15.2 Submit electronic copies of shop drawings unless otherwise directed by the Consultant. Coordinate exact requirements with the Consultant.
- 1.15.3 Submit for review, drawings showing detail design, construction, and performance of equipment and materials as requested in Specification. Submit shop drawings to the Consultant for review prior to ordering and delivery of product to site. Include minimally for preparation and submission of following, as applicable:
 - 1.15.3.1 product literature cuts;
 - 1.15.3.2 equipment data sheets;
 - 1.15.3.3 equipment dimension drawings;

- 1.15.3.4 system block diagrams;
 - 1.15.3.5 sequence of operation;
 - 1.15.3.6 connection wiring schematic diagrams;
 - 1.15.3.7 functionality with integrated systems.
 - 1.15.4 Each shop drawing or product data sheet is to be properly identified with project name and product drawing or specification reference. Shop drawing or product data sheet dimensions are to match dimension type on drawings.
 - 1.15.5 Where any item of equipment is required by Code or Standard or By-Law to meet a specific energy efficiency level, or any other specific requirement, ensure this requirement is clearly indicated on submission.
 - 1.15.6 Ensure proposed products meet each requirement of Project. Endorse each shop drawing copy "CERTIFIED TO BE IN ACCORDANCE WITH ALL REQUIREMENTS". Include company name, submittal date, and sign each copy. Shop drawings that are received and are not endorsed, dated and signed will be returned to be resubmitted.
 - 1.15.7 Consultant to review shop drawings and indicate review status by stamping shop drawing copies as follows:
 - 1.15.7.1 "REVIEWED" or "REVIEWED AS NOTED" (appropriately marked) – If Consultant's review of shop drawing is final, Consultant to stamp shop drawing;
 - 1.15.7.2 "RETURNED FOR CORRECTION" – If Consultant's review of shop drawing is not final, Consultant to stamp shop drawing as stated above, mark submission with comments, and return submission. Revise shop drawing in accordance with Consultant's notations and resubmit.
 - 1.15.8 Following is to be read in conjunction with wording on Consultant's shop drawing review stamp applied to each and every shop drawing or product data sheet submitted:
 - 1.15.8.1 "THIS REVIEW BY CONSULTANT IS FOR SOLE PURPOSE OF ASCERTAINING CONFORMANCE WITH GENERAL DESIGN CONCEPT. THIS REVIEW DOES NOT MEAN THAT CONSULTANT APPROVES DETAILED DESIGN INHERENT IN SHOP DRAWINGS, RESPONSIBILITY FOR WHICH REMAINS WITH CONTRACTOR. CONSULTANT'S REVIEW DOES NOT RELIEVE CONTRACTOR OF RESPONSIBILITY FOR ERRORS OR OMISSIONS IN SHOP DRAWINGS OR OF CONTRACTOR'S RESPONSIBILITY FOR MEETING REQUIREMENTS OF CONTRACT DOCUMENTS. BE RESPONSIBLE FOR DIMENSIONS TO BE CONFIRMED AND CORRELATED AT JOB SITE, FOR INFORMATION THAT PERTAINS SOLELY TO FABRICATION PROCESSES OR TO TECHNIQUES OF CONSTRUCTION AND INSTALLATION, AND FOR COORDINATION OF WORK OF SUB-TRADES."
 - 1.15.9 Submit each system and each major component as separate shop drawing submissions. Submit together, shop drawings for common devices such as devices of each system are to be submitted together.
 - 1.15.10 Obtain shop drawings for submission from product manufacturer's authorized representatives and supplemented with additional items specified herein.
 - 1.15.11 Do not order product until respective shop drawing review process has been properly reviewed with the Consultant.
 - 1.15.12 Where extended warranties are specified for equipment items, submit specified extended warranty with shop drawing submittal.
 - 1.15.13 Applicable mechanical equipment has been selected to meet energy efficiency requirements of ANSI/ASHRAE/IES 90.1, Energy Standards for Buildings, and shop drawings/product data submittals for such equipment must indicate compliance with this Standard or they will be returned for correction and re-submittal.
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1.16 EQUIPMENT LOADS

- 1.16.1 Supply equipment loads (self-weight, operating weight, housekeeping pad, inertia pads, etc.) to the Consultant, via shop drawing submissions, prior to construction.
- 1.16.2 Where given choice of specific equipment, actual weight, location, and method of support of equipment may differ from those assumed by the Consultant for base design. Back-check equipment loads, location, and supports, and include necessary accommodations.
- 1.16.3 Where supporting structure consists of structural steel framing, it is imperative that equipment loads, location, and method of support be confirmed prior to fabrication of structural steel. Review locations of equipment with the Consultant prior to construction.

1.17 OPENINGS

- 1.17.1 Supply opening sizes and locations to the Consultant to allow verification of their effect on design, and for inclusion on structural drawings where appropriate.
- 1.17.2 No openings are permitted through completed structure without written approval from Owner and reviewed with the Consultant. Show required openings on a copy of structural drawings. Identify exact locations, elevations, and size of proposed openings and submit to the Consultant for review, well in advance of doing work.
- 1.17.3 Prior to leaving site at end of each day, walk through areas of work and check for any openings, penetrations, holes, and/or voids created under scope of work of project, and ensure that any openings created under scope of work have been closed off, fire-stopped and smoke-sealed. Unless directed by Owner and reviewed with the Consultant, do not leave any openings unprotected and unfinished overnight.

1.18 SCAFFOLDING, HOISTING AND RIGGING

- 1.18.1 Unless otherwise specified or directed, supply, erect and operate scaffolding, rigging, hoisting equipment and associated hardware required for work, and subject to approval from Owner and reviewed with the Consultant.
- 1.18.2 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.
- 1.18.3 Do not place major scaffolding/hoisting equipment loads on any portion of structure without approval from Owner and reviewed with the Consultant.

1.19 CHANGES IN THE WORK

- 1.19.1 Whenever Consultant proposes in writing to make a change or revision to design, arrangement, quantity, or type of work from that required by Contract Documents, prepare and submit to the Consultant for review, a quotation being proposed cost for executing change or revision.
- 1.19.2 Quotation is to be a detailed and itemized estimate of product, labour, and equipment costs associated with change or revision, plus overhead and profit percentages and applicable taxes and duties.
- 1.19.3 Unless otherwise specified in Division 00 or Division 01, allowable maximum percentages for overhead and profit are to be 7% and 5% respectively.
- 1.19.4 Unless otherwise specified in Division 00 or Division 01, following additional requirements apply to all quotations submitted:
 - 1.19.4.1 when change or revision involves deleted work as well as additional work, cost of deleted work (less overhead and profit percentages but including taxes and duties) is to be subtracted from cost of additional work before overhead and profit percentages are applied to additional work;

- 1.19.4.2 material costs are not to exceed those published in the latest edition of Allpriser price guide, less the following discounts:

Item	Discount
Steel Pipe	50%
Copper Pipe	45%
Cast Iron Soil Pipe	45%
Stainless Steel Pipe and Fittings	45%
Welded Fittings	50%
Grooved Fittings	30%
Threaded Fittings	40%
Cast Iron Screwed Fittings	40%
Copper Fittings	45%
Cast Iron MJ Fittings	35%
Valves	25%
Insulation Materials	35%

- 1.19.4.3 mechanical material labour unit costs are to be in accordance with Mechanical Contractors Association of America Labor Estimating Manual, less 25%;
- 1.19.4.4 electrical material labour unit costs are to be in accordance with National Electrical Contractors Association Manual of Labor Units at difficult level, less 25%;
- 1.19.4.5 costs for journeyperson and apprentice labour must not exceed prevailing rates at time of execution of Contract and must reflect actual personnel performing work;
- 1.19.4.6 cost for site superintendent must not exceed 10% of total hours of labour estimated for change or revision, and change or revision must be such that site superintendent's involvement is necessary;
- 1.19.4.7 costs for rental tools and/or equipment are not to exceed local rental costs;
- 1.19.4.8 overhead percentage will be deemed to cover quotation costs other than actual site labour and materials, and rentals;
- 1.19.4.9 quotations, including those for deleted work, to include a figure for any required change to Contract time.
- 1.19.5 Quotations submitted that are not in accordance with requirements specified above will be rejected and returned for re-submittal. Failure to submit a proper quotation to enable Consultant to expeditiously process quotation and issue a Change Order will not be grounds for any additional change to Contract time.
- 1.19.6 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.
- 1.19.7 Do not execute any change or revision until written authorization for the change or revision has been obtained from the Consultant.

1.20 PROGRESS PAYMENT BREAKDOWN

- 1.20.1 Prior to submittal of first progress payment draw, submit a detailed breakdown of work cost to assist Consultant in reviewing and approving progress payment claims.
- 1.20.2 Payment breakdown is subject to Owner's approval and Consultant's review. Progress payments will not be processed until an approved breakdown is in place. Breakdown is to

include one-time claim items such as mobilization and demobilization, insurance, bonds (if applicable), shop drawings and product data sheets, commissioning including testing, adjusting and balancing, system testing and verification, and project closeout submittals.

- 1.20.3 Indicate equipment, material and labour costs for site services (if applicable) and indicate work of each trade in same manner as indicated on progress draw.

1.21 NOTICE FOR REQUIRED FIELD REVIEWS

- 1.21.1 Whenever there is a requirement for the Consultant to perform a field review prior to concealment of any work, to inspect/re-inspect work for deficiencies prior to Substantial Performance of the Work, for commissioning demonstrations, and any other such field review, give minimum 5 working days' notice in writing to the Consultant.
- 1.21.2 If Consultant is unable to attend a field review when requested, arrange an alternative date and time.
- 1.21.3 Do not conceal work until the Consultant advises that it may be concealed.
- 1.21.4 When Consultant is requested to perform a field review and work is not ready to be reviewed, reimburse Consultant for time and travel expenses.

1.22 PRELIMINARY TESTING

- 1.22.1 When directed by the Consultant, promptly arrange, pay for, and perform site tests on any piece of equipment or any system for such reasonable lengths of time and at such times as may be required to prove compliance with Specification and governing Codes and Regulations, prior to Substantial Performance of the Work.
- 1.22.2 When, in Consultant's opinion, tests are required to be performed by a certified testing laboratory, arrange and pay for such tests.
- 1.22.3 These tests are not to be construed as evidence of acceptance of work, and it is agreed and understood that no claim for delays or damage will be made for injury or breakage to any part or parts of equipment or system due to test where such injuries or breakage were caused by faulty parts and/or workmanship of any kind.
- 1.22.4 When, in Consultant's opinion, tests indicate that equipment, products, etc., are defective or deficient, immediately remove such equipment and/or products from site and replace them with acceptable equipment and/or products, at no additional cost.

1.23 PROVISIONS FOR SYSTEMS/EQUIPMENT USED DURING CONSTRUCTION

- 1.23.1 Permanent building mechanical systems are not to be used for temporary heating or cooling purposes during construction.

1.24 TEMPORARY SERVICES

- 1.24.1 Coordinate with Prime Contractor, requirements for temporary services including but not limited to temporary heating, cooling, and water. Unless otherwise noted, provide required services in compliance with requirements of local governing building code and local governing inspection authorities.
- 1.24.2 Maintain fire protection of areas which may include fire watch during temporary shutdowns of existing systems, in accordance with requirements of local governing code and local governing authorities.

1.25 MAINTAINING EQUIPMENT PRIOR TO ACCEPTANCE

- 1.25.1 Maintain equipment in accordance with the manufacturer's printed instructions prior to start-up, testing and commissioning.
- 1.25.2 Employ a qualified millwright to check and align shafts, drives, and couplings on all base mounted split coupled motor driven equipment.
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- 1.25.3 Where equipment lubrication fittings are not easily accessible, extend the fittings to accessible locations using copper or aluminium tubing.
- 1.25.4 All filters are to be new upon Substantial Performance of the Work. This is in addition to any spare filters specified.

1.26 RECORD DOCUMENTATION

- 1.26.1 Drawings for this project have been prepared on a CAD system using AutoCAD software of release version reviewed with the Consultant. For purpose of producing record "as built" drawings, copies of Contract Drawings can be obtained from the Consultant.
 - 1.26.2 As work progresses at site, clearly mark in red in a neat and legible manner on a set of bound white prints of Contract Drawings, changes, and deviations from routing of services and locations of equipment shown on Contract Drawings, on a daily basis. Changes and deviations include those made by addenda, change orders, and site instructions. Use notes marked in red as required. Maintain white print red line as-built set at site for exclusive use of recording as-built conditions, keep set up-to-date at all times, and ensure set is always available for periodic review. As-built set is also to include the following:
 - 1.26.2.1 dimensioned location of inaccessible concealed work;
 - 1.26.2.2 locations of control devices with identification for each;
 - 1.26.2.3 for underground piping and ducts, record dimensions, invert elevations, offsets, fittings, cathodic protection and accessories if applicable, and locate dimensions from benchmarks to be preserved after construction is complete;
 - 1.26.2.4 for fire protection systems, record actual locations of equipment, sprinkler heads, and valves, drains, and test locations, and deviations of pipe routing and sizing from that shown on the drawings;
 - 1.26.2.5 location of piping system air vents;
 - 1.26.2.6 location of concealed services terminated for future extension and work concealed within building in inaccessible locations.
 - 1.26.3 Before applying for a Certificate of Substantial Performance of the Work, update a clean copy of Contract Drawing set in accordance with marked up set of "as-built" white prints including deviations from original Contract Drawings, thus forming an "as-built" drawing set. Submit "as-built" site drawing prints to the Consultant for review. Make necessary revisions to drawings as per Consultant's comments, to satisfaction of the Consultant.
 - 1.26.4 Use final reviewed "as-built" drawing set to provide CAD files of drawings thus forming true "as-built" set of Contract Drawings. Identify set as "Project Record Copy". Load digital copies of final reviewed by the Consultant as-built drawings onto USB type flash drive. Provide 2 complete sets of "as-built" drawings on separate USBs. Submit "as-built" sets of white prints and USBs to Consultant.
 - 1.26.5 Submitted drawings are to be of same quality as original Contract Drawings. CAD drawing files are to be compatible with AutoCAD software release version confirmed with the Consultant.
 - 1.26.6 Unless otherwise noted in Division 00 or Division 01, failure to maintain accurate record drawings will incur additional 5% holdback on progress claims until drawings are brought up to date to satisfaction of Owner and reviewed with the Consultant.
 - 1.26.7 For projects with phased turnover of project (refer to Division 01), review with the Consultant completeness of as-built drawings prior to turn over of an area. Interim as-built drawings to be made available to Owner's maintenance personnel.
 - 1.26.8 Where part of the Mechanical Scope of Work, retain and pay for services of a land surveyor registered in Place of the Work to measure, verify, and record size, location, invert elevation and pitch of buried piping services, and, when complete, transfer survey work to as-built drawings.
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1.27 OPERATING AND MAINTENANCE DATA

- 1.27.1 For each item of equipment for which a shop drawing is required (except for simple equipment), supply indexed copies of equipment manufacturers' operating and maintenance (O&M) instruction data manuals. Consolidate each copy of data as a PDF file on a USB drive. Consolidated O&M manual PDF to include:
 - 1.27.1.1 front cover: project name; wording – "Mechanical Systems Operating and Maintenance Manual"; and date;
 - 1.27.1.2 introduction sheet listing Consultant, Contractor, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses;
 - 1.27.1.3 equipment manufacturer's authorized contact person name, telephone number and company website;
 - 1.27.1.4 Table of Contents sheet, and corresponding index tab sheets;
 - 1.27.1.5 copy of each "REVIEWED" or clean, updated "REVIEWED AS NOTED" shop drawing or product data sheet, with manufacturer's/supplier's name, telephone and fax numbers, email address, company website address, and email address for local source of parts and service; when shop drawings are returned marked "Reviewed As Noted" with revisions marked on shop drawing copies, they are to be revised by equipment supplier to incorporate comments marked on "Reviewed" shop drawings and a clean updated copy is to be included in operating and maintenance manuals;
 - 1.27.1.6 Operating data is to include:
 - (1) pressure test reports, and certificates issued by governing authorities;
 - (2) description of each system and its controls;
 - (3) control schematics for equipment/systems including building environmental controls;
 - (4) wiring and connection diagrams;
 - (5) if applicable, BAS architecture and all required operating data;
 - (6) description of operation of each system at various loads together with reset schedules and seasonal variances;
 - (7) operation instruction for each system and each component;
 - (8) description of actions to be taken in event of emergencies and/or equipment failure;
 - (9) valve tag schedule, and flow diagrams to indicate valve locations.
 - 1.27.1.7 Maintenance data is to include:
 - (1) operation and trouble-shooting instructions for each item of equipment and each system;
 - (2) schedules of tasks, frequency, tools required, and estimated task time;
 - (3) recommended maintenance practices and precautions;
 - (4) complete parts lists with numbers.
 - 1.27.1.8 Performance data is to include:
 - (1) equipment and system start-up data sheets;
 - (2) equipment performance verification test results, and final commissioning report;
 - (3) final testing, adjusting and balancing reports.
 - 1.27.1.9 copies of warranties;
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- 1.27.1.10 items requested specifically in Section Articles.
- 1.27.2 Operating and maintenance instructions are to relate to job specific equipment supplied under this project and related to Owner's building. Language used in manuals is to contain simple practical operating terms and language easy for in-house maintenance staff to understand how to operate and maintain each system.
- 1.27.3 Before applying for a Certificate of Substantial Performance of the Work, assemble one copy of O&M Manual and submit to the Consultant for review prior to assembling remaining copies. Incorporate Consultant's comments into final submission.

1.28 COMMISSIONING

- 1.28.1 After successful start-up and prior to Substantial Performance of the Work, commission the mechanical work. Commissioning work is the process of Contractor demonstrating to Owner and Consultant, for purpose of final acceptance, by means of successful and documented functional performance testing, that systems and/or subsystems are capable of being operated and maintained to perform in accordance with requirements of Contract Documents, as further described below.
 - 1.28.1.1 Retain services of a testing, adjusting, and balancing agency to perform testing and balancing of mechanical system air/fluid flows and capacities, prior to operational performance testing. Refer to Section 20 05 93 – Testing, Adjusting, and Balancing for Mechanical Systems.
 - 1.28.1.2 Test, adjust and operate equipment and systems after start-up but before functional performance testing, to confirm operations are in accordance with requirements of Contract Documents. Verify modes and sequences of control and monitoring, interlocks, and responses to emergency conditions. Complete commissioning data sheets to document successful operational performance testing.
 - 1.28.1.3 Repeat successful operational performance testing with completed commissioning data sheet documentation in the presence of Consultant and Owner to validate and verify equipment and systems are complete in all respects, function correctly, and are ready for acceptance.
 - 1.28.1.4 Submit final commissioning data sheets, TAB reports as specified in Section 20 05 93 – Testing, Adjusting, and Balancing for Mechanical Systems, project closeout documents, and other required submittals.

1.29 WARRANTY

- 1.29.1 Unless otherwise specified in Division 00 and Division 01, warrant mechanical work to be in accordance with Contract Documents and free from defects for a period of 1 year from date of issue of a Certificate of Substantial Performance of the Work.
 - 1.29.2 Where equipment includes extended warranty period, e.g., 5 years, first year of warranty period is to be governed by terms and conditions of warranty in Contract Documents, and remaining years of warranty are to be direct from equipment manufacturer and/or supplier to Owner. Submit signed and dated copies of extended warranties to the Consultant.
 - 1.29.3 Warranty to include parts, labour, travel costs and living expenses incurred by manufacturer's authorized technician to provide factory authorized on-site service.
 - 1.29.4 Repair and/or replace any defects that appear in Work within warranty period without additional expense to Owner. Be responsible for costs incurred in making defective work good, including repair or replacement of building finishes, other materials, and damage to other equipment. Ordinary wear and tear and damage caused wilfully or due to carelessness of Owner's staff or agents is exempted.
 - 1.29.5 Do not include Owner deductible amounts in warranties.
 - 1.29.6 It is understood that warranties are to commence from time of Substantial Performance of the Work, regardless of what is noted within following Sections of Specification. Be
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responsible for providing whatever "bridging" or additional extended warranty period is required from time that material is purchased until this time.

- 1.29.7 Visit building during warranty period with Owner representatives. Owner to organize these visits. At these meetings, Owner representatives are to review performance of systems. If performance is satisfactory, then no further action needs to be taken. If unsatisfactory, then correct deficiencies, as directed by Owner representatives, to satisfaction of Owner's representatives. These site visits to occur:
- 1.29.7.1 once during 1st month of building operation;
 - 1.29.7.2 once during 3rd month of building operation;
 - 1.29.7.3 once between 4th month and 10th month in a season opposite to 1st month and 3rd month visits.

1.30 CLOSEOUT SUBMITTALS

- 1.30.1 Prior to application for Substantial Performance of the Work, submit required items and documentation specified, including following as applicable to the project:
- 1.30.1.1 Operating and Maintenance Manuals;
 - 1.30.1.2 as-built record drawings and associated data;
 - 1.30.1.3 extended warranties for equipment as specified;
 - 1.30.1.4 operating test certificates, i.e. Sprinkler Test Certificate;
 - 1.30.1.5 final commissioning report and TAB report;
 - 1.30.1.6 identified keys for equipment and/or panels for which keys are required, and other items required to be submitted;
 - 1.30.1.7 other data or products specified.

1.31 INSTRUCTIONS TO OWNER

- 1.31.1 Refer to equipment and system operational and maintenance training requirements specified in Division 01.
- 1.31.2 Train Owner's designated personnel in aspects of operation and maintenance of equipment and systems as specified. Demonstrations and training are to be performed by qualified technicians employed by equipment/system manufacturer/supplier. Supply hard copies of training materials to each attendee.
- 1.31.3 Unless where specified otherwise in trade Sections, minimum requirements are for manufacturer/suppliers of each system and major equipment, to provide minimum two separate sessions each consisting of minimum 4 hours on site or in factory training (at Owner's choice), of Owner's designated personnel (for up to 6 people each session), on operation and maintenance procedures of system.
- 1.31.4 For each item of equipment and for each system for which training is specified, prepare training modules as specified below. Use Operating and Maintenance Manuals during training sessions. Training modules include but are not limited to:
- 1.31.4.1 Operational Requirements and Criteria – equipment function, stopping and starting, safeties, operating standards, operating characteristics, performance curves, and limitations;
 - 1.31.4.2 Troubleshooting – diagnostic instructions, test and inspection procedures;
 - 1.31.4.3 Documentation – equipment/system warranties, and manufacturer's/supplier's parts and service facilities, telephone numbers, email addresses, and the like;
 - 1.31.4.4 Maintenance – inspection instructions, types of cleaning agents to be used as well as cleaning methods, preventive maintenance procedures, and use of any special tools;
 - 1.31.4.5 Repairs – diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and components, and review of any spare parts inventory.
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- 1.31.5 Before instructing Owner's designated personnel, submit to the Consultant for review preliminary copy of training manual and proposed schedule of demonstration and training dates and times. Incorporate Consultant's comments in final copy.
- 1.31.6 Obtain in writing from the Consultant list of Owner's representatives to receive instructions. Submit to Consultant prior to application for Certificate of Substantial Performance of the Work, complete list of systems for which instructions were given, stating for each system:
 - 1.31.6.1 date instructions were given to Owner's staff;
 - 1.31.6.2 duration of instruction;
 - 1.31.6.3 names of persons instructed;
 - 1.31.6.4 other parties present (manufacturer's representative, consultants, etc.).
- 1.31.7 Obtain signatures of Owner's staff to verify they properly understood system installation, operation, and maintenance requirements, and have received operating and maintenance instruction manuals and "as-built" record drawings.
- 1.31.8 Submit to the Consultant copy of electronic version of training materials and include in operating and maintenance manuals submission.

1.32 FINAL INSPECTION

- 1.32.1 Submit to Consultant, written request for final inspection of systems. Include written certification that:
 - 1.32.1.1 deficiencies noted during job inspections have been completed;
 - 1.32.1.2 field quality control procedures have been completed;
 - 1.32.1.3 systems have been tested and verified, balanced, and adjusted, and are ready for operation;
 - 1.32.1.4 maintenance and operating data have been completed and submitted to, reviewed with the Consultant and accepted by Owner;
 - 1.32.1.5 tags and nameplates are in place and equipment identifications have been completed;
 - 1.32.1.6 clean-up is complete;
 - 1.32.1.7 spare parts and replacement parts specified have been provided and acknowledged by the Consultant;
 - 1.32.1.8 as-built and record drawings have been completed and submitted to and reviewed with the Consultant and accepted by Owner;
 - 1.32.1.9 Owner's staff has been instructed in operation and maintenance of systems;
 - 1.32.1.10 commissioning procedures have been completed.

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 CLEANING

- 3.1.1 During construction, keep site reasonably clear of rubbish and waste material resulting from work on a daily basis to the satisfaction of Owner and Consultant. Before applying for a Certificate of Substantial Performance of the Work, remove rubbish and debris, and be responsible for repair of any damage caused as a result of work.
- 3.1.2 Clean equipment and devices installed as part of this project.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for:
 - 1.1.1.1 electric motors (submit with equipment they are associated with).
- 1.1.2 Submit a list of equipment identification nameplates indicating proposed wording and sizes.

2 PRODUCTS

2.1 EQUIPMENT BELT DRIVES

- 2.1.1 ANSI/RMA Standard V-belt type rated at minimum 1.5 times motor nameplate rating, and in accordance with following requirements:
 - 2.1.1.1 belts are to be reinforced cord and rubber, and multiple belts are to be matched sets;
 - 2.1.1.2 sheaves are to be cast iron or steel, secured to shafts with removable keys unless otherwise specified, standard adjustable pitch ($\pm 10\%$ range) for motors under 10 hp, fixed pitch type with split tapered bushing and keyway for motors 10 hp and larger, and, if required, replaced as part of mechanical work to suit system air/water quantity testing and balancing work;
 - 2.1.1.3 motor slide rail adjustment plates are to allow for centre line adjustment.
- 2.1.2 Supply a spare belt set (tagged and identified) for each belt drive and hand to Owner upon Substantial Performance of the Work.

2.2 EQUIPMENT DRIVE GUARDS AND ACCESSORIES

- 2.2.1 For V-belt drives – removable, 4-sided, fully enclosed, galvanized sheet steel guards to OSHA standards, cleaned, factory primed and painted with yellow equipment enamel, complete with a 2-piece full length hinged front panel to permit belt maintenance or replacement without removing guard, and 40 mm (1-1/2") diameter tachometer openings at each shaft location.
- 2.2.2 For flexible couplings – removable "U" shaped galvanized steel guards to OSHA Standards with a 2.3 mm (3/32") thick frame and expanded mesh face.
- 2.2.3 For unprotected fan inlets and outlets – unless otherwise specified, removable 20 mm (3/4") galvanized steel wire mesh with galvanized steel frames, all to OSHA Standards.

2.3 ELECTRIC MOTORS

- 2.3.1 Unless otherwise specified, motors are to conform to NEMA Standard MG1, applicable IEEE Standards, and applicable CSA C22.2 standards, and are to meet NEMA standards for maximum sound level ratings under full load. Confirm motor voltages prior to ordering.
 - 2.3.2 Vertically mounted and submersible motors are to be purposely designed for mounting in this attitude.
 - 2.3.3 Efficiency of 1-phase motors to 1 hp is to be in accordance with CAN/CSA C747. Efficiency of 3-phase motors 1 hp and larger is to be in accordance with CAN/CSA C390 or IEEE 112B.
 - 2.3.4 Unless otherwise specified, 1-phase motors smaller than 1/2 hp are to be 115 V, continuous duty capacitor start type with an NEMA 48 or 56 frame size, solid base, heavy-gauge steel shell with solid die-cast end shields, dynamically balanced die-cast rotor, integral automatic reset thermal overload protection, Class "B" insulation, and a 1.15 service factor at 40°C (105°F) ambient temperature.
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- 2.3.5 Explosion-proof 1-phase motors are to be totally enclosed, fan cooled, 115 V continuous duty capacitor start type in accordance with CSA C22.2 No. 145, as specified for standard 1-phase motors but suitable for use in Class 1 Group D hazardous locations and complete with a rolled steel shell and a 1.0 service factor at 40°C (105°F) ambient temperature.
- 2.3.6 Unless otherwise specified, motors ½ hp and larger are to be totally enclosed, fan cooled, 3-phase, T-frame, squirrel cage continuous duty induction motors suitable for voltages indicated on Drawings, NEMA Design "B" for normal starting torque or Design "C" for high starting torque as required by the application, each complete with Class "B" insulation, a 1.15 service factor at 40°C ambient temperature, grease lubricated open ball bearings with grease fittings to permit re-lubrication without dismantling motor, a cast iron frame with cast iron feet where required, cast iron end bracket and precision machined bearing fit, and balanced carbon steel shaft assembly with die-cast aluminum rotor windings.
- 2.3.7 Explosion-proof 3-phase motors are to be totally enclosed fan cooled motors in accordance with CSA C22.2 No. 145, generally as specified above for standard 3-phase motors but suitable for use in Class 1 Group D hazardous locations and with a 1.0 service factor at 40°C (105°F) ambient temperature.
- 2.3.8 Motor(s) for 2-speed cooling tower(s) are to be as specified above but 2-speed single winding type.
- 2.3.9 Motor(s) for 2-speed fan(s) are to be as above but 2-speed double winding type.
- 2.3.10 Unless otherwise indicated, motors 30 hp and larger are to be complete with a heat sensing PTC thermistor in the end turn of stator winding for each phase and connected in series inside motor with 2 marked leads brought out to motor conduit box.
- 2.3.11 Motors for equipment with variable frequency drives are to be generally as specified above but inverter duty type to NEMA Standard MG 1 Part 31, quantified by CSA for operation from a variable frequency drive of type specified, and complete with Class "H" insulation. Motors are to be equipped with AEGIS, or approved equal, shaft grounding ring system to protect bearings from damage by diverting harmful shaft voltages and bearing currents to ground.
- 2.3.12 Motors 150 hp and larger with "wye-delta" reduced voltage starters are to be complete with six leads for connection to motor starter.
- 2.3.13 Motors for equipment which is scheduled or specified with a corrosion resistant coating or constructed from corrosion resistant materials are to be factory coated with a primer and epoxy paint finish.
- 2.3.14 Manufacturers:
 - 2.3.14.1 TECO-Westinghouse Motors (Canada) Inc.;
 - 2.3.14.2 Canadian General Electric;
 - 2.3.14.3 Baldor Electric Co.;
 - 2.3.14.4 U.S. Electrical Motors;
 - 2.3.14.5 Weg Electric Corp.;
 - 2.3.14.6 Marathon Electric;
 - 2.3.14.7 Toshiba Corp.;
 - 2.3.14.8 Leeson Canada.

2.4 MOTOR STARTERS AND ACCESSORIES

- 2.4.1 Motor starters must be capable of starting associated motors under the imposed loads. Confirm starter voltage matches motor prior to ordering.
 - 2.4.2 Unless otherwise specified, starters for 1-phase motors are to be 115 V, thermal overload protected manual starting switches with a neon pilot light, a surface or recessed
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- enclosure to suit the application, and, where automatic operation is required, a separate H-O-A switch in an enclosure to match starter enclosure.
- 2.4.3 Unless otherwise specified, starters for 3-phase motors less than 50 hp are to be combination "quick-make" and "quick-break" fused disconnects and full voltage non-reversing across-the-line starters, each complete with and overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.
- 2.4.4 Unless otherwise specified, starters for 3-phase motors 50 hp to 150 hp are to be reduced voltage, non-reversing, auto-transformer type starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.
- 2.4.5 Unless otherwise specified, starters for 3-phase motors 150 hp and larger are to be reduced voltage, non-reversing, closed transition "wye-delta" starters complete with one overload relay per phase, an enclosure to suit the application, and, a H-O-A switch, pilot lights, control transformer, auxiliary contacts, and other accessories as per motor starter schedule.
- 2.4.6 Starters for 2-speed double winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.
- 2.4.7 Starters for 2-speed single winding motors are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to permit equipment to coast down to low speed before it is operated at low speed.
- 2.4.8 Starters for reversible motors for cooling towers are to be generally as specified above but suitable for motor and equipped with a 45 second time delay to allow fan(s) to coast down to a stop before being operated in reverse rotation.
- 2.4.9 Unless otherwise specified, motor starter enclosures are to be in accordance with following NEMA ratings:
- 2.4.9.1 enclosures located in sprinklered areas – Type 2;
 - 2.4.9.2 enclosures exposed to the elements – Type 3R, constructed of stainless steel;
 - 2.4.9.3 enclosures inside the building in wet areas – Type 3R, constructed of stainless steel;
 - 2.4.9.4 enclosures in explosion rated area – Type 7 with exact requirements to suit the area and application;
 - 2.4.9.5 enclosures except as noted above – Type 1;
 - 2.4.9.6 enclosures located in finished areas – as above but recess type with brushed stainless steel faceplate.
- 2.4.10 Motor control centres are to be multi-unit, 2.28 m (9') high, NEMA Class 1, type "B", factory assembled, dead front, floor mounted, free-standing motor control centre with tin plated copper bus and an NEMA Type 1 or Type 2 enclosure as for loose starters specified above. Each motor control centre is to be complete with starters as specified above, load and control wiring terminal boards, and required facilities for line and load side power wiring connections.
- 2.4.11 Disconnect switches for motor control centres are to be heavy-duty, CSA certified, front operated switches as per motor starter schedule, each complete with a handle suitable for padlocking in "off" position and arranged so that door cannot be opened with handle in "on" position and an NEMA enclosure as specified for loose starters. Fusible units are to be complete with fuse clips to suit fuse types specified below.
- 2.4.12 Fuses are to be, unless otherwise scheduled or specified, English Electric Ltd. HRC fuses, Form I Class "J" for constant running equipment and Form II Class "C" for equipment that cycles on and off.
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- 2.4.13 Manufacturers:
 - 2.4.13.1 Rockwell Automation Inc. - Allen-Bradley;
 - 2.4.13.2 Eaton Corp. – Cutler-Hammer;
 - 2.4.13.3 Eaton Corp. – Moeller Electric;
 - 2.4.13.4 Siemens Canada;
 - 2.4.13.5 Schneider Electric.

2.5 *SPRINKLER PROOFING*

- 2.5.1 Provide drip shields for protection of surface mounted equipment enclosures from water spray and dripping of liquids. Features of shields include:
 - 2.5.1.1 factory constructed by respective equipment manufacturers;
 - 2.5.1.2 constructed from non-combustible materials (sheet steel);
 - 2.5.1.3 enamel painted to match equipment;
 - 2.5.1.4 surfaces and edges filled/sanded smooth prior to painting;
 - 2.5.1.5 supported from equipment with structural steel rods/metal framing or other method approved by Consultant;
 - 2.5.1.6 structural support finish painted to match shield.
- 2.5.2 Include with equipment shop drawings, detailed dimensions of drip shields and methods of supporting.
- 2.5.3 Equipment with top cable/conduit entries to include additional sealing of entries with gasketing and/or waterproof sealant to prevent water from entering enclosure.
- 2.5.4 Design ventilation louvers such that live components are not exposed to water spray and dripping liquids.
- 2.5.5 Above requirements are additional minimum "sprinkler proof" standards for equipment specified as NEMA 1, 2 or 12.
- 2.5.6 Obtain CSA approval where required by local governing authorities.

3 EXECUTION

3.1 *INSTALLATION OF EQUIPMENT DRIVE GUARDS AND ACCESSORIES*

- 3.1.1 Provide OHSA guards for exposed accessible rotating parts such as belt drives, couplings, fan wheels, and shaft ends on mechanical equipment.
- 3.1.2 Install belt guards to allow movement of motors for adjusting belt tension.
- 3.1.3 Provide a means to permit lubrication and use of test instruments with guards in place.
- 3.1.4 Secure guards to equipment or equipment base but do not bridge sound or vibration isolation.
- 3.1.5 Where equipment oil level gauges, oil reservoirs, grease cups, or grease gun fittings are integral with equipment but are not easily accessible for service, extend to an accessible location using aluminium or copper tubing.

3.2 *SUPPLY OF MOTOR STARTERS AND ACCESSORIES*

- 3.2.1 Unless otherwise shown or specified, supply a starter for each item of motorized equipment. Refer to Motor Starter Schedule.
 - 3.2.2 Where 3-phase starters are indicated in motor control centres, supply motor control centres with starters and bolt to a concrete housekeeping pad.
 - 3.2.3 Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with equipment is fed from a motor control centre, provide a disconnect switch in motor control centre in lieu of a motor starter.
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- 3.2.4 Where 3-phase starters are indicated and/or scheduled to be mounted on a motor starter panel, starters will be mounted and connected, complete with panels and splitter trough, as part of electrical work. Hand starters to electrical trade at site when they are required.
- 3.2.5 Where package type equipment with integral starters, or equipment with starters integral in loose power and control panels supplied with equipment is fed from a motor starter panel, a disconnect switch will be provided on motor starter panel as part of electrical work.
- 3.2.6 Unless otherwise specified or shown on drawings, 1-phase motor starters will be mounted adjacent to equipment they serve and connected complete as part of electrical work. Hand starters to electrical trade at site at the proper time.

3.3 ELECTRICAL WIRING WORK FOR MECHANICAL WORK

- 3.3.1 Unless otherwise specified or indicated, following electrical wiring work for mechanical equipment will be done as part of the electrical work:
 - 3.3.1.1 "line" side power wiring to motor starters or disconnect switches in motor control centres and starters or disconnects on motor starter panels, and "load" side wiring from starters or disconnects to equipment.
 - 3.3.1.2 "line" side power wiring to individual wall mounted starters, and "load" side wiring from starters to equipment.
 - 3.3.1.3 "line" side power wiring to pre-wired power and control panels and variable frequency drives (VFD), and "load" side power wiring from the panels and VFD's to equipment.
 - 3.3.1.4 provision of receptacles for plug-in equipment.
 - 3.3.1.5 provision of disconnect switches for motors in excess of 10 m (30 ft) from starter location, or cannot be seen from starter location, and associated power wiring.
 - 3.3.1.6 motor starter interlocking in excess of 24 V.
 - 3.3.1.7 wiring from motor winding thermistors in motors 30 hp and larger to motor starter contacts.
 - 3.3.1.8 120 V power connections to electrical receptacles integral with small ceiling exhaust fans.
 - 3.3.1.9 120 V power connections to small exhaust fans, and ceiling fans for all line voltage control devices, including but not limited to wiring through toggle switches, line voltage thermostats, countdown timer switches, or line voltage speed controllers. Coordinate requirements with Electrical Division.
 - 3.3.1.10 120 V wiring connections to lighting fixture/switch combinations integral with air handling units.
 - 3.3.1.11 120 V wiring connections to duplex receptacles integral with air handling unit control panels.
 - 3.3.1.12 120 V wiring connections to BAS system controllers/panels and other control system or component requiring 120 V power including, but not limited to, VAV boxes, dampers, low voltage transformers, etc.
- 3.3.2 Mechanical wiring work not listed above or specified herein or on drawings to be done as part of electrical work is to be installed in conduit and is to be done as part of mechanical work in accordance with wiring requirements specified for electrical work.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Shop Drawings/Product Data: Submit shop drawings with product data sheets for variable frequency drives (VFDs). Include:
 - 1.1.1.1 construction and performance details;
 - 1.1.1.2 wiring and control schematics;
 - 1.1.1.3 dimensions of units;
 - 1.1.1.4 calculations specific to installation showing total harmonic voltage distortion is less than 5%;
 - 1.1.1.5 certified production test results with serial numbers for harmonic mitigation performance and energy efficiency under actual variable frequency drive loading.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Certification Letter: Submit a start-up and installation certification letter from supplier of VFDs as specified in Part 3 of this Section;
- 1.2.2 Parameters: Prepare list of parameters for uploading for Owner's future use as specified in Part 3 of this Section. Load on USB type flash drive and submit to the Consultant.
- 1.2.3 Extended Warranty: Where extended warranty is specified to be included, include a copy of VFD extended warranty in each Operating and Maintenance Manual. Prior to Substantial Performance of Work, submit a copy of warranty to Owner.
- 1.2.4 Additionally, coordinate with Prime Contractor and Electrical Contractor to ensure that shop drawings clearly identify that proposed VFDs and connected motors are 100% compatible and Mechanical Contractor to sign off on selected VFDs.
- 1.2.5 Additionally, coordinate with Prime Contractor and Mechanical Contractor to ensure that shop drawings clearly identify that proposed VFDs and connected motors are 100% compatible and that Mechanical Contractor has signed off on selected VFDs.

1.3 COORDINATION WITH ELECTRICAL DIVISIONS

- 1.3.1 This Section specifies VFD requirements for motors. Ensure that VFDs packaged with various system equipment, complies with specifications of this Section.
- 1.3.2 VFDs are each to be approved by respective manufacturers of VFDs and connected motors, as suitable for installation on scheduled motors. VFD output current rating to match or exceed connected motor nameplate full load current rating.
- 1.3.3 Coordinate and review with Electrical Divisions, responsibility requirements for supply of VFDs, harmonic filters and requirements for control and power conductors and connections.
- 1.3.4 Check that motors are equipped with AEGIS or approved equal, shaft grounding ring system to protect bearings from damage in motors by diverting harmful shaft voltages and bearing currents to ground.
- 1.3.5 Additionally, review and confirm responsibilities with Consultant and Prime Contractor.

1.4 COORDINATION WITH MECHANICAL DIVISIONS

- 1.4.1 This Section specifies VFD requirements for Mechanical Division motors. Mechanical Divisions Contractor and trades to ensure that VFDs packaged with their equipment, complies with specifications of this Section.
 - 1.4.2 VFDs are each to be approved by respective manufacturers of VFDs and connected motors, as suitable for installation on scheduled motors. VFD output current rating to match or exceed connected motor nameplate full load current rating.
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- 1.4.3 Coordinate with Mechanical Divisions, responsibility requirements for supply of VFDs and harmonic filters. Do not supply VFDs that are pre-packaged with mechanical equipment and supplied as part of Work of Mechanical Divisions.
- 1.4.4 Check that motors supplied by Mechanical Divisions and which are to be connected to VFDs, are equipped with AEGIS or approved equal, shaft grounding ring system to protect bearings from damage in motors by diverting harmful shaft voltages and bearing currents to ground. Identify in writing to Consultant any motors without such requirements.
- 1.4.5 Additionally, confirm responsibilities with Consultant and Prime Contractor.

1.5 WARRANTY

- 1.5.1 VFDs to be warranted free from defective labour and materials for period of 36 months from date of Substantial Performance of the Work. Include for initial one year Contract warranty and an additional 2 year extended warranty direct to Owner. Extended warranty terms and conditions are to be identical to one year Contract warranty, and extended warranty period is to commence day Contract warranty expires.

2 PRODUCTS

2.1 VFD BASIC REQUIREMENTS

- 2.1.1 VFDs supplied on project to be products of same manufacturer and be CSA approved, ULC listed and labelled. Base specified product is ABB ACH series units that include compliance with following standards:
 - 2.1.1.1 CSA C22.2 No.14 Industrial Control Equipment;
 - 2.1.1.2 UL 508 - Industrial Control Equipment;
 - 2.1.1.3 UL 508C – Power Conversion Equipment;
 - 2.1.1.4 NEMA ICS 7 - Adjustable-Speed Drives.
 - 2.1.2 Basis for limiting harmonics is to be provided generally to IEEE Standard 519 - Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, except intended for user's electrical distribution system with point of common coupling (where harmonic limits are assessed) to be set at input terminals of harmonic mitigating equipment.
 - 2.1.3 Refer to Schedule of VFDs on drawings for features to include with respective VFDs.
 - 2.1.4 VFDs to include following basic requirements:
 - 2.1.4.1 regardless of HP rating are to be of same VFD model; I/O and control circuit boards as well as keypads are to be identical and interchangeable regardless of HP rating;
 - 2.1.4.2 to be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without safety tripping or component damage (flying start);
 - 2.1.4.3 6-pulse width modulated (PWM) AC to AC converter utilizing latest isolated gate bipolar transistor (IGBT) technology; PWM switching pattern to include a motor flux optimization circuit that automatically reduces applied motor voltage to the motor to optimize energy consumption and audible motor noise;
 - 2.1.4.4 carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency without derating VFD or operating at high carrier frequency only at low speeds;
 - 2.1.4.5 provisions that determine motor torque and flux every 25 microseconds (40,000 times per second);
 - 2.1.4.6 completely assembled and tested by manufacturer in their facility;
 - 2.1.4.7 designed to provide at least 250,000 hours mean time before failure (MTBF) when specified preventative maintenance is performed.
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- 2.1.4.8 bypass system completely factory wired and tested;
- 2.1.4.9 door interlocked padlockable disconnect switch that disconnects all input power from drive and all internally mounted options;
- 2.1.4.10 control panel keyboard and display with password protection against parameter changes.

2.2 VFD RATINGS

- 2.2.1 VFDs to be rated to operate from 3 phase input voltage of 208 V or 600 V \pm 10%, as scheduled, and frequency range from 48 Hz to 63 Hz. In addition, a tolerated voltage window to allow system to operate from a line of +30% to -35% nominal voltage. System to incorporate circuitry that allows drive or bypass contactor to remain "sealed in" over this voltage tolerance at a minimum.
- 2.2.2 VFDs to employ a full wave rectifier to prevent input line notching and operate at a minimum fundamental input power factor of 0.97 at all speeds and loads.
- 2.2.3 VFDs efficiency to be 96% or better at full speed and load.
- 2.2.4 Output voltage and current ratings to match adjustable frequency operating requirements of standard 3-ph, 60 Hz, NEMA design B inverter-duty motors in compliance with NEMA MG 1, Part 31 Standard. Overload current capacity for variable torque overload capacity to be 110% of rated current for 1 minute out of 10 minutes and 130% for 2 seconds. Output frequency to be adjustable between 0 and 500 Hz.
- 2.2.5 Open loop static speed regulation to be 0.1% to 0.3% (10% of motor slip). Dynamic speed accuracy to be 4%-sec. or better open loop.
- 2.2.6 When a suitable motor is used, drive provides breakaway torque equal to 200% of rated motor torque. Torque response time to be 5 ms or less.
- 2.2.7 Enclosures:
 - 2.2.7.1 in climate controlled areas – minimum NEMA 12 with drip shield;
 - 2.2.7.2 in non-climate controlled areas – NEMA 3R.

2.3 HARMONIC FILTERS AND REACTORS

- 2.3.1 VFDs to include internal 5% impedance AC line reactor (or equivalent 5% impedance dual positive and negative DC bus reactors) provided as a standard to reduce input current harmonic content and provide isolation from power line transients and to reduce RFI emissions.
- 2.3.2 VFDs serving motors sized 11 kW (15 hp) or more to be provided with harmonic filters to limit harmonics distortion produced by each drive to following maximum levels as measured on input side of drive:
 - 2.3.2.1 Total harmonic distortion (voltage) – 5%;
 - 2.3.2.2 Total harmonic distortion (current) – 10%.
- 2.3.3 Harmonic filter to be based on MIRUS International Inc. "LINEATOR AUHF" series, with features as follows:
 - 2.3.3.1 manufactured and tested in accordance with latest applicable standards of ULC, CSA and NEMA;
 - 2.3.3.2 treat characteristic low frequency harmonics generated by a 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.);
 - 2.3.3.3 passive inductor/capacitor network;
 - 2.3.3.4 low capacitive reactance (KVAR) of less than 20% of kVA rating, to ensure compatibility with engine generator sets;
 - 2.3.3.5 full load efficiency of harmonic mitigation equipment / VFD combination to be greater than 96%;
 - 2.3.3.6 copper wiring;
 - 2.3.3.7 220°C system insulation class and temperature rise of 130°C;
 - 2.3.3.8 anti-vibration pads between reactor or transformer core and enclosure;

2.3.3.9 manufacturer's standard ventilated, NEMA 3R enclosure.

2.4 CONTROLS AND ADJUSTMENT FUNCTIONS

2.4.1 Include for following:

- 2.4.1.1 programmable critical frequency lockout ranges to prevent VFD from operating load continuously at an unstable speed;
- 2.4.1.2 proportional integral derivative (PID) speed loop regulators with an auto tune function as well as manual adjustments; PID set point controllers to allow pressure or flow signals to be connected to VFD, using microprocessor in VFD for closed loop control; includes 250 mA of 24 VDC auxiliary power and capability of loop powering a transmitter supplied by others; two parameter sets for first PID that allow sets to be switched via a digital input, serial communications or from keypad for night setback, summer/winter set points, etc.; independent, second PID loop that can utilize second analogue input and modulate analogue outputs to maintain set point of an independent process (i.e. valves, dampers, etc.); set points, process variables, etc. to be accessible from serial communication network;
- 2.4.1.3 programmable analogue inputs that accept current or voltage signals.
- 2.4.1.4 programmable analogue outputs (0-20 mA or 4-20 mA), that may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data;
- 2.4.1.5 programmable digital inputs;
- 2.4.1.6 programmable digital Form-C relay contact outputs for programmable on and off delay times and adjustable hysteresis; rated for maximum switching current 8 A at 24 VDC and 0.4 A at 250 VAC; maximum voltage 300 VDC and 250 VAC; continuous current rating 2 A RMS;
- 2.4.1.7 run permissive circuit - for damper or valve control; dry contact closure that will signal damper to open (VFD motor does not operate); when damper is fully open, a normally open dry contact (end-switch) closes; closed end-switch is wired to a VFD digital input and allows motor operation; two separate safety interlock inputs, when either is opened, motor to coast to stop, and damper to close;
- 2.4.1.8 two independently adjustable accel and decel ramps with 1-1800 seconds adjustable time ramps;
- 2.4.1.9 fireman's override input - upon receipt of a contact closure from fireman's control station, VFD operates in one of two modes: operate at a programmed predetermined fixed speed or operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback; mode overrides all other inputs (analogue/digital, serial communication and keypad commands), except customer defined safety run interlock, and forces motor to run in one of the two modes; "Override Mode" to be displayed on control panel; upon removal of override signal, VFD resumes normal operation.

2.4.2 Operator Control Panel:

- 2.4.2.1 front mounted plug-in operator control panel consisting of keypad, multi-line backlit LCD display for programming and fault diagnostics;
 - 2.4.2.2 keys (switches) for HAND, OFF, AUTO, and manual speed control INCREASE/DECREASE;
 - 2.4.2.3 menu navigation and parameter selection keys for custom programming;
 - 2.4.2.4 date and time clock - clock to have a battery backup with 10 years minimum life span; clock to be used to date and time stamp faults and record operating parameters at time of fault; if battery fails VFD I automatically reverts to hours of operation since initial power up; clock also to be programmable to control
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- start/stop functions, constant speeds, PID parameter sets and output relays; VFD to have a digital input that allows an override to time clock (when in off mode) for a programmable time frame; four (4) separate, independent timer functions that have both weekday and weekend settings;
- 2.4.2.5 parameter names, fault messages, warnings and other information to be displayed in complete words or standard abbreviations to allow user to understand what is being displayed without use of a manual or cross reference table, as follows:
- (1) "HAND" position to start drive and modify reference frequency by use of INCREASE/DECREASE keys;
 - (2) "OFF" position stops drive;
 - (3) "AUTO" position allows drive to be started or stopped using whichever remote start/stop command configured; drive speed controlled by external speed reference input or by PID controller.
 - (4) applicable operating values to be capable of being displayed in engineering (user) units; operating displayed include:
 - (A) Output Frequency;
 - (B) Motor Speed (RPM, %, or Engineering units);
 - (C) Motor Current;
 - (D) Drive Temperature;
 - (E) DC Bus Voltage;
 - (F) Output Voltage.

2.5 PROTECTIVE FUNCTIONS

- 2.5.1 For each programmed warning and fault protection function, keypad displays a message in complete words or standard abbreviations.
 - 2.5.2 VFDs include metal oxide varistors (MOV's) for phase to phase and phase to ground line voltage transient protection.
 - 2.5.3 Short circuit current rating of 100,000 amps to be provided per UL 508C without relying on line fuses.
 - 2.5.4 Ground fault protection, motor phase loss protection and phase unbalance protection to be provided. Single phase protection to be provided on input and output.
 - 2.5.5 VFDs to provide electronic motor overload protection qualified per UL 508C.
 - 2.5.6 Protection to be provided for AC line or DC bus overvoltage at 130% of maximum rated or undervoltage at 65% of minimum rated.
 - 2.5.7 Stall protection to be programmable to provide a warning or stop VFD after motor has operated above a programmable torque level for a programmed time limit.
 - 2.5.8 Underload protection to be programmable to provide a warning or stop VFD after motor has operated below a selected underload curve for a programmed time limit.
 - 2.5.9 Overtemperature protection to provide a warning if power module temperature is less than 5C° (9 F) below overtemperature trip level.
 - 2.5.10 Input terminal to be provided for connecting a motor thermistor (PTC type) to drive's protective monitoring circuitry. An input to also be programmable to monitor an external relay or switch contact.
 - 2.5.11 VFDs through 56 kW (75 hp) to be protected from damage from input and output power miss-wiring. VFD to sense this condition and display an alarm on control panel.
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- 2.5.12 EMI / RFI filters to be provided as per standard EN 61800-3.
- 2.5.13 dv/dt long lead filter (LRC) to protect power system network.
- 2.5.14 Automatic reset feature to automatically reset selected faults and attempt to restart drive based on control parameters such as adjustable time delays, number of restart attempts and duration of restart attempts. Faults include following:
 - 2.5.14.1 Overcurrent;
 - 2.5.14.2 Overvoltage;
 - 2.5.14.3 Undervoltage;
 - 2.5.14.4 Analogue input signal reference loss;
 - 2.5.14.5 External fault.
- 2.5.15 Additional built-in protection circuits include:
 - 2.5.15.1 Overcurrent trip limit;
 - 2.5.15.2 Undervoltage trip limit;
 - 2.5.15.3 Microprocessor fault;
 - 2.5.15.4 Keypad control panel loss;
 - 2.5.15.5 Serial communication loss;
 - 2.5.15.6 External fault interlock inputs;
 - 2.5.15.7 Adjustable output frequency and motor speed limits;
 - 2.5.15.8 Pass code parameter change protection;
 - 2.5.15.9 Keypad operator control lockout.

2.6 ELECTRONIC BYPASS

- 2.6.1 Electronic bypass system to be a fully operational horsepower rated manual and automatic system for full speed operation without VFD, with following components and features:
 - 2.6.1.1 factory wired and tested microprocessor controlled bypass system consisting of an output contactor and bypass contactor, service (isolation) switch and VFD input fuses; (bypass designs, which have no VFD only fuses, or that incorporate fuses common to both VFD and bypass will not be accepted);
 - 2.6.1.2 bypass enclosure door and VFD enclosure to be interlocked such that input power is turned off before either enclosure can be opened;
 - 2.6.1.3 door interlocked padlockable disconnect switch that disconnects all input power from drive and all internally mounted devices;
 - 2.6.1.4 following operators:
 - (1) bypass Hand-Off-Auto;
 - (2) drive mode selector and light;
 - (3) bypass mode selector and light;
 - (4) bypass fault reset;
 - (5) bypass LCD display, 2 lines for programming and status / fault / warning indications.
 - 2.6.1.5 motor protection from single phase power conditions; bypass system to detect a single phase input power condition while running in bypass, disengage motor in a controlled fashion, and give a single phase input power indication;
 - 2.6.1.6 bypass system does not depend on VFD for bypass operation; bypass to be completely functional in both Hand and Automatic modes even if VFD is removed from enclosure for repair / replacement;
 - 2.6.1.7 run permissive circuit - for damper or valve control; dry contact closure that will signal damper to open (VFD motor does not operate); when damper is fully open, a normally open dry contact (end-switch) closes; closed end-switch is wired to a VFD digital input and allows motor operation; two separate safety

- interlock inputs, when either is opened, motor to coast to stop, and damper to close;
- 2.6.1.8 bypass control to monitor status of VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil; this failed contactor operation to be indicated on Bypass LCD display as well as over serial communications protocol;
- 2.6.1.9 bypass control to include a programmable time delay for bypass start and control panel indication that this time delay is in process; this allows VAV boxes to be driven open before motor operates at full speed in bypass mode; time delay to be field programmable from 0 – 120 seconds;
- 2.6.1.10 bypass control to be programmable for manual or automatic transfer to bypass; user to be able to select via control panel programming which drive faults will generate an automatic transfer to bypass and which faults require a manual transfer to bypass;
- 2.6.1.11 adjustable motor current sensing circuit for bypass and VFD mode to provide proof of flow indication; condition is indicated on control panel display, transmitted over building automation protocol and on a relay output contact closure;
- 2.6.1.12 programmable digital inputs, and programmable Form-C relay outputs;
- 2.6.1.13 relay outputs from bypass to be programmable for any of following indications:
- (1) system started;
 - (2) system running;
 - (3) bypass override enabled;
 - (4) drive fault;
 - (5) bypass fault;
 - (6) bypass H-O-A position;
 - (7) motor proof of flow (broken belt);
 - (8) overload;
 - (9) bypass selected;
 - (10) bypass run;
 - (11) system started (damper opening);
 - (12) bypass alarm;
 - (13) over temperature.
- 2.6.1.14 digital inputs for system accept 24 VAC or 24 VDC; bypass incorporates internally sourced power supply and does not require an external control power source; bypass power board to supply 250 mA of 24 VDC for use by others to power external devices;
- 2.6.1.15 interlock terminal strip: provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command; external safety interlocks to remain fully functional whether system is in VFD or bypass mode; remote start/stop contact to operate in VFD and bypass modes; terminal strip allows for independent connection of up to four (4) unique safety inputs;
- 2.6.1.16 User is able to select text to be displayed on keypad when safety opens; example text display indications include "Firestat", "Freezestat", "Over pressure" and "Low pressure"; user is able to determine which of four (4) safety contacts is open over serial communications connection;
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- 2.6.1.17 Class 10, 20, or 30 (selectable) electronic motor overload protection is included as required for specific applications.

2.7 MANUAL BYPASS

- 2.7.1 Bypass system to be a fully operational horsepower rated manual system for full speed operation without VFD, with following components:
 - 2.7.1.1 VFD and By-pass output contactors, mechanically and electrically interlocked to allow only one mode of operation at one time;
 - 2.7.1.2 service switch or contactor to isolate VFD from supply;
 - 2.7.1.3 VFD input fuses;
 - 2.7.1.4 door mounted VFD/OFF/BY-PASS selector switch;
 - 2.7.1.5 VFD ON and BY-PASS ON indicator lights;
 - 2.7.1.6 door mounted HAND/OFF/AUTO switch if Hand operation is unavailable at VFD control panel;
 - 2.7.1.7 terminals for external customer safety interlocks.
- 2.7.2 Bypass designs, which have no VFD only fuses, or that incorporate fuses common to both VFD and bypass are not acceptable.
- 2.7.3 Door interlocked padlockable fused disconnect switch that supplies power to VFD and bypass, and disconnects input power from drive, bypass and all internally mounted devices.

2.8 COMMUNICATIONS

- 2.8.1 VFD to be complete with communications connections of integrated RS-485 port suitable to allow for VFD to be controlled, supervised, monitored and programmed from one remote control panel or PC with VFD system Windows based application software.
 - 2.8.2 Communications protocol to be industry standard compatible to BAS of building. Coordinate exact requirements with Mechanical Divisions controls contractor and BAS vendor to ensure that appropriate interface module is supplied for drive system to communicate with BAS being used in building with interface capability to include serial communication standard protocols as follows:
 - 2.8.2.1 ModBus;
 - 2.8.2.2 Johnson Controls Metasys N2;
 - 2.8.2.3 Siemens Building Technologies FLN;
 - 2.8.2.4 BACnet.
 - 2.8.3 Serial communication to be used for drive setup, diagnostic analysis, monitoring and control with capabilities to include, but not be limited to:
 - 2.8.3.1 run-stop control;
 - 2.8.3.2 speed set adjustment;
 - 2.8.3.3 proportional/integral/derivative PID control adjustments;
 - 2.8.3.4 current limit;
 - 2.8.3.5 accel/decel time adjustments;
 - 2.8.3.6 ability to lock and unlock control panel keypad;
 - 2.8.3.7 capability of allowing BAS to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature;
 - 2.8.3.8 monitoring relays output status, and digital input status and analogue output values;
 - 2.8.3.9 transmitting diagnostic warning and fault information over communications bus to BAS or other monitoring system;
 - 2.8.3.10 remote fault reset.
-

- 2.8.4 Serial communication and Windows based software to be used for drive setup, diagnostic analysis, monitoring and control. Software to provide real time graphical displays of drive performance. VFD software communication capabilities include, but not be limited to:
 - 2.8.4.1 system ON/OFF;
 - 2.8.4.2 system status;
 - 2.8.4.3 Suitable input for speed control;
 - 2.8.4.4 run-stop control;
 - 2.8.4.5 ability to force unit to bypass;
 - 2.8.4.6 ability to lock and unlock control panel keypad;
 - 2.8.4.7 allowing BAS to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and logic board temperature;
 - 2.8.4.8 monitoring relays output status, and all digital input status;
 - 2.8.4.9 transmitting diagnostic warning and fault information over communications bus to BAS or other monitoring system;
 - 2.8.4.10 remote fault reset;
 - 2.8.4.11 keypad "Hand" or "Auto" selected, and status indications and settings transmitted over serial communications bus;
 - 2.8.4.12 monitor if motor is running under load in both VFD and bypass (proof of flow) in VFD mode over serial communications or Form-C relay output;
 - 2.8.4.13 minimum of 40 field parameters to be capable of being monitored in bypass mode.

2.9 SITE SERVICES, TRAINING, AND MAINTENANCE MANUALS

- 2.9.1 Provide onsite inspection, testing, start up and verification work of VFDs and filters by manufacturer's authorized technician. Allow a minimum of 1/2 day per system. Also include for a second visit to site of one (1) day duration to train operating personnel in operation and maintenance of drives. Provide verification reports and supply soft copy of system programming parameters.
- 2.9.2 Upon completion of installation, supplier of VFDs to supply minimum one hard copy of complete sets of service and maintenance manuals including wiring and connection diagrams. Include for digital copy loaded onto a USB type flash drive.
- 2.9.3 Provide system training and instructions on operating and maintenance procedures. Refer to additional requirements in General Instructions section and Division 01.
- 2.9.4 Include for manufacturer's authorized technician to be in attendance to assist Commissioning Agent during commissioning process.

2.10 MANUFACTURERS

- 2.10.1 Manufacturer List:
 - 2.10.1.1 ABB;
 - 2.10.1.2 Schneider Electric (Square D);
 - 2.10.1.3 Rockwell Automation;
 - 2.10.1.4 Eaton Cutler Hammer;
 - 2.10.1.5 Siemens Electric;
 - 2.10.1.6 Control Techniques.

3 EXECUTION

3.1 INSTALLATION OF VARIABLE FREQUENCY DRIVES

- 3.1.1 Provide variable frequency drives for motorized equipment in accordance with drawing requirements. Coordinate requirements for conductors and connections with Electrical Divisions Contractor.
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- 3.1.2 Ensure that variable speed drives supplied are products of same manufacturer.
 - 3.1.3 Unless otherwise noted on drawings or in Part 2 of this Section, include minimally, a manual bypass with each VFD. Supply electronic bypass with VFDs specifically noted and/or scheduled on drawings.
 - 3.1.4 Ensure wire length between VFD and motor is less than 15 m (50') with properly sized conductors.
 - 3.1.5 Install VFDs in accordance with manufacturer's instructions. Ensure that VFDs installation include upstream protection, either fuses or circuit breakers in accordance with VFD manufacturer's recommendations and local electrical code requirements. Advise Electrical Divisions Contractor of these requirements in addition to required conductors and connections. Provide required control wiring and connections.
 - 3.1.6 Review VFD and related connected motor installation. Provide local disconnect to VFD in accordance with local governing code requirements.
 - 3.1.7 Mount VFDs operating controls/display at approximately 1.5 m (5') above finished floor level, unless otherwise directed by the Consultant. Provide dual back to back C-channel support system from floor to ceiling, complete with cross bracing to form a solid backing for VFD mounting at required locations.
 - 3.1.8 Properly support VFDs. Coordinate exact locations on site with the Consultant.
 - 3.1.9 Where VFDs are required for custom made air handling units VFDs to be supplied, factory mounted on fan cabinets, and "load" side connected to fan motors by air handling unit manufacturer. "Line" side power wiring to these VFDs to be provided as part of Electrical Divisions work.
 - 3.1.10 Where VFDs are required for commercial fans, mount each VFD generally where shown but with exact location to ensure that VFD is accessible in accordance with local governing electrical code requirements. "Line" and "load" side power wiring to these VFD's to be provided as part of Electrical Divisions work.
 - 3.1.11 Where VFDs are required for pumps, mount each VFD generally where shown but with exact location to ensure that VFD is accessible in accordance with local governing electrical code requirements. "Line" and "load" side power wiring to these VFDs to be provided as part of Electrical Divisions work.
 - 3.1.12 Install harmonic mitigation filter equipment as follows:
 - 3.1.12.1 in accordance with manufacturer's recommended installation practices and to comply with applicable local governing codes;
 - 3.1.12.2 provide each VFD as specified in per Part 2, with a harmonic filter sized as per manufacturer's rating table to match rating of connected VFD;
 - 3.1.12.3 mount harmonic filters sized up to 110 kW (150 hp) typically to wall/ceiling construction using suitable brackets, metal C-channel framework and vibration isolators assemblies, ensuring full support of units acceptable to local governing authorities;
 - 3.1.12.4 mount harmonic filters sized greater than 110 kW (150 hp) typically to floor mounted concrete pads with suitable vibration isolators and seismic restraints in accordance with local governing building codes;
 - 3.1.12.5 ensure that adequate ventilation and space for access is provided;
 - 3.1.12.6 review exact locations with the Consultant prior to installation;
 - 3.1.12.7 coordinate with Electrical Division Contractor to ensure units are connected complete to line side supply feed and to VFD in accordance with VFD manufacturer's instructions for standalone VFDs and VFD system with bypass; include required control wiring and connections.
 - 3.1.13 Ground and bond equipment as per local governing electrical code requirements and manufacturer's instructions.
-

- 3.1.14 Provide engraved lamacoid nameplate identifying each piece of equipment. Review exact nomenclature with the Consultant.
- 3.1.15 Be responsible for ensuring that VFDs, harmonic filters and connected motors are properly installed, connected, tested in proper working order and operation verified.

3.2 INSTALLATION OF VARIABLE FREQUENCY DRIVES

- 3.2.1 Provide VFDs for motorized mechanical equipment in accordance with drawing requirements and coordinated with mechanical equipment vendors and Mechanical Divisions Contractor.
 - 3.2.2 Ensure that VFDs supplied for project are products of same manufacturer.
 - 3.2.3 Unless otherwise noted on drawings or in Part 2 of this Section, include minimally, a manual bypass with each VFD. Supply electronic bypass with VFDs specifically noted and/or scheduled on drawings.
 - 3.2.4 Supply and install wiring and connections to VFDs and harmonic filters are to recommendations of VFD Manufacturer. Ensure wire length between VFD and motor is less than 15 m (50') with properly sized conductors. Obtain required wiring diagrams from equipment vendors. Provide required control wiring and connections.
 - 3.2.5 Install VFDs in accordance with manufacturer's instructions.
 - 3.2.6 Review VFD and related connected motor installation. Provide local disconnect (fusible switch or breaker) to VFD in accordance with local governing electrical code requirements and VFD manufacturer instructions. Confirm requirements with VFD vendor.
 - 3.2.7 Mount VFDs operating controls/display at approximately 1.5 m (5') above finished floor level, unless otherwise directed by the Consultant. Provide dual back to back C-channel support system from floor to ceiling, complete with cross bracing to form a solid backing for VFD mounting at required locations.
 - 3.2.8 Properly support VFDs. Coordinate exact locations on site with Mechanical Divisions Contractor and review with the Consultant.
 - 3.2.9 Coordinate installation and control of VFDs with Mechanical Division Contractor and Controls Contractor. Confirm communications protocol required for compatibility with BAS and ensure VFD system includes for proper protocol.
 - 3.2.10 Install harmonic mitigation filter equipment as follows:
 - 3.2.10.1 to be handled, stored and installed in accordance with manufacturer's recommended installation practices and to comply with applicable local governing codes;
 - 3.2.10.2 provide each VFD as specified in per Part 2, with a harmonic filter sized as per manufacturer's rating table to match rating of connected VFD;
 - 3.2.10.3 mount harmonic filters sized up to 110 kW (150 hp) typically to wall/ceiling construction using suitable brackets, metal C-channel framework and vibration isolators assemblies, ensuring full support of units acceptable to local governing authorities;
 - 3.2.10.4 mount harmonic filters sized greater than 110 kW (150 hp) typically to floor mounted concrete pads with suitable vibration isolators and seismic restraints in accordance with local governing building codes;
 - 3.2.10.5 ensure that adequate ventilation and space for access is provided;
 - 3.2.10.6 review exact locations with the Consultant prior to installation;
 - 3.2.10.7 provide required conductors and connections in accordance with filter manufacturer's instructions; obtain required wiring diagrams from equipment vendors;
 - 3.2.10.8 connect complete to line side supply feed and to VFD in accordance with VFD manufacturer's instructions for standalone VFDs and VFD system with bypass.
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- 3.2.11 Ground and bond equipment as per local governing code requirements and manufacturer's instructions. Refer also to requirements of grounding and bonding article.
- 3.2.12 Provide engraved lamacoid nameplate identifying each piece of equipment. Review nomenclature with the Consultant.
- 3.2.13 Be responsible for ensuring that VFDs, harmonic filters and connected motors are properly installed, connected, tested in proper working order and operation verified.

3.3 TESTING, START-UP, AND VERIFICATION

- 3.3.1 When installation of VFDs are complete, arrange for VFD manufacturer/supplier to:
 - 3.3.1.1 supply factory authorized technician at site for minimum of 4 hours per system to examine installation and connection of each VFD, and to perform start-up and set-up procedures in conjunction with equipment start-up and testing procedures;
 - 3.3.1.2 supply factory authorized technician at site for minimum of one 8 hour day to train Owner's personnel on VFD operating and maintenance procedures;
 - 3.3.1.3 prepare and submit letter to certify that VFDs have been properly installed, tested and adjusted, and are in proper operating condition;
 - 3.3.1.4 submit list of start-up and testing parameters for uploading for future use by Owner.
 - 3.3.2 Start-up data entries to include motor nameplate power, speed, voltage, frequency and current.
 - 3.3.3 Inspect VFDs and accessories for verification of proper operation and installation.
 - 3.3.4 Inspect interface wiring to BAS for verification of proper operation and installation.
 - 3.3.5 Verification of wire terminations to VFDs and bypass and to operational circuitry.
 - 3.3.6 Installation verification of VFD, bypass and motor being driven for proper operation and reliability.
 - 3.3.7 Verification that connections and communications to BAS or other monitoring/remote control system are of proper operation and installation and of full communications compatibility.
 - 3.3.8 Measurement for verification of proper operation on each of following items:
 - 3.3.8.1 Motor voltage and frequency;
 - 3.3.8.2 Verification of proper motor operation;
 - 3.3.8.3 Control input for proper building automation system interface and control calibration.
 - 3.3.9 Calibration check for following set points (and adjustment as necessary):
 - 3.3.9.1 minimum speed;
 - 3.3.9.2 maximum speed;
 - 3.3.9.3 acceleration and deceleration rates.
 - 3.3.10 Verify harmonic compliance with onsite field measurements of both voltage and current harmonic distortion at point of common coupling-input terminals of harmonic mitigating equipment with and without equipment operating. Utilize recording type Fluke 41 or equivalent harmonics analyser displaying individual and total harmonic currents and voltages.
 - 3.3.11 Document testing and results in a report signed by a Professional Engineer licensed in the Place of Work and authorized by system manufacturer. Include for minimum 3 hard copies and electronic copy of report to be submitted to the Consultant for review.
 - 3.3.12 Additionally, refer to applicable installation, testing, coordination and verification requirements in Electrical Divisions Sections.
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- 3.3.13 Coordinate procedures specified above to be performed by VFD manufacturer/supplier authorized technician with system commissioning work.

END OF SECTION

1 GENERAL

1.1 SLEEVE AND FORMED OPENING LOCATION DRAWINGS

- 1.1.1 Prepare and submit for review, drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.
- 1.1.2 Such drawings are to be completely and accurately dimensioned and relate sleeve, recesses, and formed openings to suitable grid lines and elevation datum, and are to take into account structural items such as grade beams, column caps, and column drop slabs.
- 1.1.3 Begin to prepare such drawings immediately upon notification of acceptance of bid and award of Contract.

2 PRODUCTS

2.1 PIPE SLEEVES

- 2.1.1 Galvanized Sheet Steel – Minimum 16 gauge galvanized steel with an integral flange at one end to secure sleeve to formwork construction.
- 2.1.2 Polyethylene – Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.
- 2.1.3 Waterproof Galvanized Steel Pipe – Schedule 40 mild galvanized steel pipe with a welded-on square steel anchor and water stop plate at sleeve midpoint.
- 2.1.4 Galvanized Steel or Cast Iron Pipe – Schedule 40 mild galvanized steel, or Class 4000 cast iron.

2.2 FIRESTOPPING AND SMOKE SEAL MATERIALS

- 2.2.1 Ensure all sealant and fire stopping is low VOC type in accordance with LEED.
- 2.2.2 Asbestos-free elastomeric materials tested, listed and labelled by ULC in accordance with ULC S115 and ULC S101 for installation in ULC designated firestopping and smoke seal systems to provide a positive fire, water and smoke seal, and a fire-resistance rating (flame, hose stream and temperature) not less than fire resistance rating of surrounding fire rated construction.
- 2.2.3 Materials are to be compatible with abutting dissimilar materials and finishes and complete with primers, damming and back-up materials, supports, and anchoring devices in accordance with firestopping manufacturer's recommendations and ULC tested assembly.
- 2.2.4 Pipe insulation forming part of a fire and smoke seal assembly is specified in Section entitled Mechanical Insulation.
- 2.2.5 Manufacturers:
 - 2.2.5.1 A/D Fire Protection Systems "FIREBARRIER";
 - 2.2.5.2 Tremco Inc. Fire Protection Systems Group "TREMSTOP";
 - 2.2.5.3 3M Canada;
 - 2.2.5.4 Hilti (Canada) Ltd. Firestop Systems;
 - 2.2.5.5 Specified Technologies Inc.

2.3 WATERPROOFING SEAL MATERIALS

- 2.3.1 Modular, mechanical seal assemblies consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and pipe sleeve or wall opening, assembled with stainless steel bolts and pressure plates and designed so when bolts are tightened the links expand to seal the opening watertight. Select seal assemblies to suit pipe size and sleeve size or wall opening size.
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- 2.3.2 Manufacturers:
 - 2.3.2.1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;
 - 2.3.2.2 The Metraflex Co. "MetraSeal" type ES.

2.4 PIPE ESCUTCHEON PLATES

- 2.4.1 One-piece chrome plated brass or #4 finish type 302 stainless steel plates with matching screws for attachment to building surface, each plate sized to completely cover pipe sleeve or building surface opening, and to fit tightly around pipe or pipe insulation.

3 EXECUTION

3.1 INSTALLATION OF PIPE SLEEVES

- 3.1.1 Where pipes pass through concrete and/or masonry surfaces provide pipe sleeves as follows:
 - 3.1.1.1 in poured concrete slabs – unless otherwise specified, minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves;
 - 3.1.1.2 in concrete or masonry walls – Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe.
- 3.1.2 Sleeves in waterproofed slabs or walls are to be lengths of Schedule 40 mild galvanized steel pipe with a waterstop plate in accordance with drawing detail. Provide waterproof sleeves in following locations:
 - 3.1.2.1 in mechanical room floor slabs, except where on grade;
 - 3.1.2.2 in slabs over mechanical, fan, electrical and telephone equipment rooms or closets;
 - 3.1.2.3 in floors equipped with waterproof membranes;
 - 3.1.2.4 in roof slab;
 - 3.1.2.5 in waterproof walls.
- 3.1.3 Size sleeves, unless otherwise specified, to leave 12 mm ($\frac{1}{2}$ ") clearance around pipes, or where pipe is insulated, a 12 mm ($\frac{1}{2}$ ") clearance around pipe insulation.
- 3.1.4 Pack and seal void between pipe sleeves and pipe or pipe insulation in non-fire rated construction for the length of sleeves as follows:
 - 3.1.4.1 pack sleeves in interior construction with mineral wool and seal both ends of sleeves with non-hardening silicone base caulking compound;
 - 3.1.4.2 pack sleeves in exterior walls above grade with mineral wool and seal both ends of sleeves water-tight with approved non-hardening silicone base caulking compound unless mechanical type seals have been specified;
 - 3.1.4.3 seal sleeves in exterior walls below grade (and any other wall where water leakage may be a problem) with link type mechanical seals as specified.
- 3.1.5 Where sleeves are required in masonry work, accurately locate and mark sleeve location, and hand sleeves to mason for installation.
- 3.1.6 Terminate piping for sleeves that will be exposed so sleeve is flush at both ends with building surface so sleeve may be completely covered by an escutcheon plate, except for sleeves in waterproof floors which are to terminate 100 mm (4") above finished floor.
- 3.1.7 "Gang" type sleeving will not be permitted.
- 3.1.8 Where sleeves are provided in non-fire rated construction for future piping, or where piping has been removed from existing sleeves, cap and seal both ends of sleeved opening.

3.2 INSTALLATION OF WATERPROOF MECHANICAL SEALS

- 3.2.1 Provide watertight link type mechanical seals in exterior wall openings.
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- 3.2.2 Assemble and install each mechanical seal in accordance with manufacturer's instructions.
- 3.2.3 After installation, periodically check each mechanical seal installation for leakage and, if necessary, tighten link seal bolts until seal is completely watertight.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for:
 - 1.1.1.1 pressure gauges and thermometers;

2 PRODUCTS

2.1 PRESSURE GAUGES AND THERMOMETERS

- 2.1.1 Pressure gauges as follows:
 - 2.1.1.1 adjustable, glycerine filled, 100 mm or 115 mm (4" or 4-½") diameter and each accurate to within 1% of scale range;
 - 2.1.1.2 type 304 stainless steel case with relief valve and polished stainless steel bayonet;
 - 2.1.1.3 stainless steel rotary movement with stainless steel bushings and socket;
 - 2.1.1.4 clear acrylic window;
 - 2.1.1.5 dual scale white dial with a scale range such that working pressure of system is at approximate mid-point of scale;
 - 2.1.1.6 black pointer.
- 2.1.2 Pressure gauge accessories and additional requirements as follows:
 - 2.1.2.1 a bronze ball type shut-off valve is to be provided in the piping to each pressure gauge;
 - 2.1.2.2 each pressure gauge for piping and equipment with normal everyday flow is to be equipped with a brass pressure snubber;
 - 2.1.2.3 each pressure gauge for steam piping or steam equipment is to be equipped with a steel coil syphon;
 - 2.1.2.4 pressure gauges in fire protection piping must be ULC listed and labelled;
- 2.1.3 Thermometers as follows:
 - 2.1.3.1 round, 125 mm (5") diameter, adjustable (90°) angle bimetal dial type thermometers, each accurate to within 1% of full scale;
 - 2.1.3.2 hermetically sealed stainless steel case with stainless steel ring;
 - 2.1.3.3 dampened bimetal coil;
 - 2.1.3.4 calibration adjustment screw;
 - 2.1.3.5 white aluminum dual scale dial with black and blue markings and a range such that working temperature of system is approximate mid-point of the scale;
 - 2.1.3.6 black aluminum pointer;
 - 2.1.3.7 double strength glass window;
 - 2.1.3.8 12 mm (½") NPT connection with 6.4 mm (¼") diameter stainless steel stem;
 - 2.1.3.9 suitable thermowell.
- 2.1.4 Manufacturers:
 - 2.1.4.1 H.O. Trerice Co.;
 - 2.1.4.2 Weiss Instruments;
 - 2.1.4.3 Ashcroft.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Provide pressure gauges in following locations where applicable:
 - 3.1.1.1 in valved tubing across suction, suction strainer (if applicable), and discharge piping of each circulating pump;

- 3.1.1.2 in supply and return piping connections to main mechanical plant equipment such as boilers, chillers, heat exchangers, main coils, etc.;
- 3.1.1.3 in expansion tank(s);
- 3.1.1.4 in separate domestic hot water storage tank(s);
- 3.1.1.5 at top most outlet in each standpipe fire protection system riser;
- 3.1.1.6 in piping at each side of a pressure reducing valve;
- 3.1.1.7 in potable water service piping downstream of meter;
- 3.1.1.8 wherever else shown and/or specified.
- 3.1.2 Provide thermometers in following locations where applicable:
 - 3.1.2.1 in supply and return piping connections to main mechanical plant equipment such as boilers, chillers, cooling towers, heat exchangers, main coils, etc., unless temperature indication is supplied with equipment;
 - 3.1.2.2 wherever else shown and/or specified.
- 3.1.3 Conform to following installation requirements where applicable:
 - 3.1.3.1 for installation of thermometers in piping wells, provide a coat of metallic base heat transfer paste or grease in piping well;
 - 3.1.3.2 for pressure gauges in piping at equipment locations, install pressure gauge between equipment and first pipe fitting;
 - 3.1.3.3 locate, mount and adjust instruments so they are easily readable;
 - 3.1.3.4 where pressure gauges and/or thermometers are located at high level or in an area where they cannot be easily seen, provide remote reading instruments.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Provide hangers and supports to secure equipment in place, prevent vibration, maintain grade, provide for expansion and contraction and to accommodate insulation; provide insulation protection saddles.
- 1.1.2 Install supports of strength and rigidity to suit loading without unduly stressing building. Locate adjacent to equipment to prevent undue stresses in piping and equipment.
- 1.1.3 Select hangers and supports for the service and in accordance with the manufacturer's recommended maximum loading. Hangers shall have a safety factor of 5 to 1.
- 1.1.4 Fasten hangers and supports to building structure.
- 1.1.5 Provide and set sleeves required for equipment, including openings required for placing equipment.
- 1.1.6 Dielectrically isolate dissimilar metals.

1.2 REFERENCES

- 1.2.1 Pipe supports shall meet the requirements of ANSI/ASME B31.1-1995, Power piping.
- 1.2.2 Automatic sprinkler pipe supports shall meet the requirements of NFPA 13-1996, Standard for the Installation of Sprinkler Systems.
- 1.2.3 Duct hangers shall follow the recommendations of the SMACNA Duct Manuals.

2 PRODUCTS

2.1 PROHIBITED MATERIALS

- 2.1.1 Use of perforated band iron, wire or chain as hangers is not permitted.

2.2 PIPING HANGERS AND SUPPORTS

- 2.2.1 Pipe hanger and support materials, including accessories, are to be, unless otherwise specified, in accordance with Manufacturers Standardization Society (MSS) Standard Practice Manual SP-58, Pipe hangers and Supports-Materials, Design and Manufacture, and where possible, MSS designations are indicated with each product specified below. Conform to following requirements:
 - 2.2.1.1 unless otherwise specified, ferrous hanger and support products are to be electro-galvanized;
 - 2.2.1.2 hangers and supports for insulated piping are to be sized to fit around insulation and insulation jacket.
- 2.2.2 Hangers and supports for horizontal suspended piping as follows:
 - 2.2.2.1 adjustable steel clevis hanger – MSS Type 1;
 - 2.2.2.2 adjustable swivel ring band hanger – MSS Type 10;
 - 2.2.2.3 adjustable roller hanger – MSS Types 41, 43, and/or 45, with MSS Type 39 steel protection saddle.
- 2.2.3 Supports for horizontal pipe on vertical surfaces as follows:
 - 2.2.3.1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
 - 2.2.3.2 heavy-duty steel pipe clip – MSS Type 26;
 - 2.2.3.3 single steel pipe hook – Myatt Fig. 156;
 - 2.2.3.4 epoxy coated steel pipe stays are not permitted.
- 2.2.4 Floor supports for vertical risers as follows:
 - 2.2.4.1 copper tubing riser clamp – MSS Type 8;
 - 2.2.4.2 heavy-duty steel riser clamp – MSS Type 8.

- 2.2.5 Supports for vertical piping on vertical surfaces as follows:
 - 2.2.5.1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
 - 2.2.5.2 heavy-duty steel pipe bracket or soil pipe bracket – MSS Type 26;
 - 2.2.5.3 extension split pipe clamp – MSS Type 12;
 - 2.2.5.4 epoxy coated steel pipe stays are not permitted.
 - 2.2.6 Base support for vertical risers in excess of 6 m (20') high extending out from base mounted equipment is to consist of a base elbow support with flange.
 - 2.2.7 For horizontal pipe on racks, Unistrut or equal galvanized steel pipe racks with pipe securing hardware as follows:
 - 2.2.7.1 standard galvanized steel U-bolts/clamps supplied by rack manufacturer;
 - 2.2.7.2 adjustable roller chair – MSS Type 44 with MSS Type 39 steel protection saddle.
 - 2.2.8 Special hangers and supports for various applications as follows:
 - 2.2.8.1 vibration isolated riser supports – black steel riser clamps as specified above, complete with neoprene–steel–neoprene sandwich type vibration isolation pads between clamp and floor;
 - 2.2.8.2 for groups of pipes having same slope – MSS Type 32 welded steel brackets, Anvil Fig. 46 universal trapeze assemblies, or Unistrut or equal support assemblies, all with U-bolts, clamps, etc., to secure pipes in place;
 - 2.2.8.3 for sections of piping connected to vibration isolated equipment – hangers and supports as specified above but complete with MSS Type 48 spring cushions;
 - 2.2.8.4 for piping on new roofs – Lexcor "Flash-Tite" or Thaler Roofing Specialties Products Inc. "MERS" Series insulated aluminum support risers with diameter, height, securement method and flashing to suit the application, channel type aluminum cross members, and galvanized steel pipe hangers and supports conforming to MSS SP-58, complete with all required accessories;
 - 2.2.8.5 for glass drain and vent piping – special padded hangers supplied by pipe supplier;
 - 2.2.8.6 for plastic piping – generally as specified above but in accordance with pipe manufacturer's recommendations;
 - 2.2.8.7 for fire protection piping – generally as above but ULC listed and/or FM approved, and in accordance with Chapter requirements of NFPA Standard applicable to piping system;
 - 2.2.8.8 for bare horizontal copper piping – generally as above but factory vinyl coated to prevent direct copper/steel contact;
 - 2.2.8.9 for bare copper vertical piping – corrosion resistant ferrous clamps with flexible rubber gasket type material (not tape) to isolate pipe from clamp;
 - 2.2.8.10 insulation protection shields to and including 40 mm (1-½") dia. – MSS Type 40 galvanized steel shields with ribs to keep shield centred on hanger.
 - 2.2.9 Hanger rods are to be electro-galvanized carbon steel (unless otherwise specified), round, threaded, to ASTM A36, complete with captive machine nuts with washers at hangers, sized to suit loading in accordance with Table 3 in MSS SP-58, but in any case, minimum 9.5 mm (3/8") diameter.
 - 2.2.10 Manufacturers:
 - 2.2.10.1 E. Myatt & Co. Inc.;
 - 2.2.10.2 Anvil International Inc.;
 - 2.2.10.3 Empire Industries Inc.;
 - 2.2.10.4 Hunt Manufacturing Ltd.;
 - 2.2.10.5 Unistrut Canada Ltd.;
 - 2.2.10.6 Nibco Inc. "Tolco";
 - 2.2.10.7 Taylor Pipe Supports.
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3 EXECUTION

3.1 INSTALLATION OF FASTENING AND SECURING HARDWARE

- 3.1.1 Provide fastening and securing hardware required for mechanical work to maintain installations attached to structure or to finished floors, walls, and ceilings in a secure and rigid manner capable of withstanding dead loads, live loads, superimposed dead loads, and any vibration of installed products.
- 3.1.2 Use fasteners compatible with structural requirements, finishes and types of products to be connected. Do not use materials subject to electrolytic action or corrosion where conditions are liable to cause such action.
- 3.1.3 Where floor, wall or ceiling construction is not suitable to support loads, provide additional framing or special fasteners to ensure proper securement to structure that is to support the products. Provide reinforcing or connecting supports where required to distribute loading to structural components.
- 3.1.4 Obtain written consent before using explosive actuated fastening devices. If consent is obtained, comply with requirements of CAN/CSA Z166.1 and CAN/CSA Z166.2.
- 3.1.5 Do not attach fasteners to steel deck without written consent from the Consultant.

3.2 INSTALLATION OF PIPE HANGERS AND SUPPORTS

- 3.2.1 Provide required pipe hangers and supports.
- 3.2.2 Provide any additional structural steel channels, angles, inserts, beam champs and similar accessories required for hanging or supporting pipe. Unless otherwise shown or specified, hang or support pipes from structure only.
- 3.2.3 For insulated pipe, size hanger or support to suit diameter of insulated pipe and install hanger or support on outside of insulation and insulation finish.
- 3.2.4 Support requirements for underground piping are as follows:
 - 3.2.4.1 support underground pipe, unless otherwise specified, on a well compacted bed of dry, natural, undisturbed earth free from rocks or protrusions of any kind, or on compacted material as specified;
 - 3.2.4.2 support underground service piping penetrating building exterior walls or foundations to prevent pipe damage if minor building settlement occurs;
 - 3.2.4.3 ensure bedding and supports for underground pipes are flat and true and allowances are made for pipe hubs, couplings, or other protrusions so no voids are left between pipe and bedding.
- 3.2.5 Unless otherwise shown or specified, hang and/or support horizontal pipe above ground by means of hangers and/or supports specified in Part 2 of this Section. Unless otherwise shown or specified, hangers for suspended pipe less than or equal to 25 mm (1") dia. are to be clevis type or adjustable ring type, and hangers for suspended pipe greater than or equal to 40 mm (1-½") dia. are to be adjustable clevis type.
- 3.2.6 Space hangers and supports in accordance with following:
 - 3.2.6.1 cast iron pipe – hang or support at every joint with maximum 2.4 m (8') spacing;
 - 3.2.6.2 plastic pipe – conform to pipe manufacturer's recommended support spacing;
 - 3.2.6.3 glass pipe – conform to pipe manufacturer's recommended support spacing and support requirements;
 - 3.2.6.4 copper and steel pipe – hang or support at spacing in accordance with following schedule:

Pipe dia.	Max. Spacing Steel	Max. Spacing Copper
to 25 mm (1")	2.4 m (8')	1.8 m (6')

Pipe dia.	Max. Spacing Steel	Max. Spacing Copper
40 mm (1-1/2")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')
65 mm (2-1/2")	3.6 m (12')	3.0 m (10')
75 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3-1/2")	3.6 m (12')	3.6 m (12')
100 mm (4")	4.2 m (14')	3.6 m (12')
250 mm (10")	6.0 m (20')	
300 mm (12")	6.7 m (22')	

- 3.2.6.5 flexible grooved pipe/coupling joint piping – as above but with not less than one hanger or support between joints;
- 3.2.7 Where pipes change direction, either horizontally or vertically, provide a hanger or support on horizontal pipe not more than 300 mm (12") from elbow, and where pipes drop from tee branches, support tees in both directions not more than 50 mm (2") on each side of tee.
- 3.2.8 When pipes with same slope are grouped and a common hanger or support is used, space hanger or support to suit spacing requirement of smallest pipe in group and secure pipes in place on common hanger or support.
- 3.2.9 Provide roller hangers or supports for heat transfer piping greater than or equal to 150 mm (6") diameter and conveying a material 75°C (170°F) or greater to facilitate pipe movement due to expansion and contraction, and at each hanger or support tack weld a steel protection saddle to pipe to protect piping insulation.
- 3.2.10 Unless otherwise shown or specified, support vertical piping by means of supports specified in Part 2 of this Section, spaced in accordance with following:
- 3.2.10.1 support vertical pipes at maximum 3 m (10') intervals or at every floor, whichever is lesser;
- 3.2.10.2 for sections of vertical piping with a length less than 3 m (10'), support pipe at least once;
- 3.2.10.3 for vertical cast iron plain end pipe (mechanical joint type), secure riser or pipe clamp around pipe under a flange integral with pipe for vertical support purposes, or provide a length of hub and spigot pipe to facilitate proper support;
- 3.2.10.4 for vertical steel pipe risers in excess of 3 m (10'), weld shear lugs to pipe to carry load;
- 3.2.10.5 for vibration isolated piping risers, provide rubber-steel-rubber vibration isolation pads between riser clamps and floor.
- 3.2.11 Support piping on the roof as follows:
- 3.2.11.1 on new roof – supply manufactured roof supports as per Part 2 of this Section to accommodate piping involved and support spacing specified above, and hand supports to roofing trade on roof for installation as part of roofing work, then secure piping in place on supports.
- 3.2.12 Each hanger, support or securement for horizontal bare copper tubing is to be plastic coated to prevent direct contact between pipe and ferrous hanger. Each wall or floor clamp for vertical bare copper piping is to be isolated from pipe by means of strips of flexible rubber inserts. Use of painted ferrous hangers and supports, including those painted with copper coloured paint, is not acceptable. Site application of tape or other types of isolation is not acceptable.

- 3.2.13 For insulated horizontal piping less than or equal to 40 mm (1-½") diameter, provide galvanized steel insulation protection shields between insulation and hanger or support. Install shields immediately after pipe is insulated.
- 3.2.14 Do not support piping from steel deck without written consent from the Consultant.

3.3 EQUIPMENT BASES AND SUPPORTS

- 3.3.1 Unless otherwise specified or required, set floor mounted equipment on minimum 100 mm (4") high reinforced concrete housekeeping pads 200 mm (8") clear of equipment on each side and end, or a minimum of 200 mm (8") from centreline of equipment anchor bolts to edge of the base, whichever is larger. Conform to following requirements:
 - 3.3.1.1 supply dimensioned drawings and equipment base templates, and provide anchor bolts for proper setting and securing of equipment on pads;
 - 3.3.1.2 place anchor bolts during concrete pour and be responsible for required levelling, alignment, and grouting of equipment;
 - 3.3.1.3 as a minimum, use wire mesh reinforcement, however, for pads for large heavy equipment, use reinforcement as per structural drawing details.
- 3.3.2 For equipment not designed for base mounting, where required, provide welded, cleaned, and prime coat painted structural steel stands or supports conforming to following requirements:
 - 3.3.2.1 provide stands and supports, except those for small equipment, designed by a structural engineer registered in jurisdiction of the work, and submit stamped and signed design drawings with calculations as shop drawings for review;
 - 3.3.2.2 flange bolt steel stands to concrete housekeeping pads;
 - 3.3.2.3 seismically restrained stands and supports in accordance with applicable requirements.
- 3.3.3 Where indicated on mechanical drawings, provide welded, cleaned and prime coat painted structural steel platforms, designed by a structural engineer registered in the jurisdiction of the work, for service access to equipment. Submit stamped and signed design drawings with calculations as shop drawings for review. Conform to following requirements:
 - 3.3.3.1 platforms in accordance with OHS requirements and adequately sized, braced, anchored, and, as required, seismically restrained;
 - 3.3.3.2 flooring equal to Fisher & Ludlow "Tru-Weld" Type 19-4, Borden type W/B (19-W-4), welded steel bar type grating;
 - 3.3.3.3 support legs constructed of welded Schedule 40 black steel pipe with welded steel cross-bracing, securely anchored and sway braced;
 - 3.3.3.4 safety guard rails, constructed from minimum 32 mm (1-¼") dia. Schedule 40 black steel pipe, for all platforms and complete with vertical stanchions at maximum 1.2 m (48") centres, top and intermediate horizontal railing, and toe plates at floor;
 - 3.3.3.5 vertical ladders constructed of Schedule 40 black steel pipe, 25 mm (1") dia. for equal height rungs, 40 mm (1-½") for stringers, anchored to floors and walls and sway braced as required;
 - 3.3.3.6 ships ladders, used wherever space conditions permit, of welded steel construction, climbing at an approximate 60° angle, and complete with channel iron stringers, open grate equal height risers approximately 165 mm (6-½") wide and factory made by grating manufacturer, handrails, and suitable anchoring and support.

3.4 CONCRETE WORK FOR MECHANICAL EQUIPMENT BASES AND PADS

- 3.4.1 Unless otherwise specified in Division 03, provide poured concrete work, including reinforcing and formwork, required for mechanical equipment bases/pads. Perform concrete work in accordance with requirements specified in Division 03.
- 3.4.2 Unless otherwise specified in Division 03, concrete is to be minimum 20,700 kPa ready-mix concrete in accordance with CAN/CSA-A23.1 and the Ontario Building Code.
- 3.4.3 Submit for review, dimensioned shop drawings, prepared and stamped by a professional structural engineer registered in the jurisdiction of the work, for concrete pads or bases for support of large, heavy equipment. Indicate on shop drawings total weight of pad or base as well as equipment it is provided for, and concrete reinforcing.
- 3.4.4 Ensure that bases and pads are keyed into the structure to meet seismic restraint requirements where applicable.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit heating cable and control shop drawings/product data sheets, complete with control schematics.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit a start-up certification letter from cable supplier as specified in Part 3 of this section.
- 1.2.2 Submit certified cable megger test reports as specified in Part 3 of this section.

2 PRODUCTS

2.1 DOMESTIC HOT WATER TEMPERATURE MAINTENANCE CABLE

- 2.1.1 Raychem Canada Ltd. "HWAT-Plus", CSA approved, 120 V, 1 phase heating cable sets to maintain temperature in domestic hot water piping, each set as specified/scheduled on drawings and complete with a Raychem AMC-1B thermostat set at 45°C (115°F), and following:
 - 2.1.1.1 required lengths of "HWAT-P1" self-regulating heating cable;
 - 2.1.1.2 "RayClic-PC" power connection with end seal per circuit;
 - 2.1.1.3 "RayClic-T" tee connections with end seals as required for pipe branches;
 - 2.1.1.4 "RayClic-S" splice connections as required;
 - 2.1.1.5 GT-66 glass tape to secure cable on pipe, and "Electric Traced" adhesive labels to be secured to pipe insulation.
 - 2.1.1.6 Complete with integral ground fault protection.
- 2.1.2 Manufacturers:
 - 2.1.2.1 Raychem Canada Ltd.;
 - 2.1.2.2 Dimplex/Chromalox Inc.;
 - 2.1.2.3 Tyco Thermal Controls/Pyrotenax.

2.2 PIPE FREEZE PROTECTION HEATING CABLE

- 2.2.1 Raychem Canada Ltd. "XL-Trace-CR" CSA certified, self-regulating piping freeze protection cable sets as specified and/or scheduled on drawings, each set complete with:
 - 2.2.1.1 required lengths of "XL-TRACE" self-regulating heating cable;
 - 2.2.1.2 power connection with end seal per circuit;
 - 2.2.1.3 tee connections with end seals as required for pipe branches;
 - 2.2.1.4 splice connections as required;
 - 2.2.1.5 GT-66 glass tape to secure cable on pipe, and "Electric Traced" adhesive labels to be secured to pipe insulation;
 - 2.2.1.6 pipe temperature sensing thermostat.
 - 2.2.1.7 Complete with integral ground fault protection.
 - 2.2.1.8 C910-485 microprocessor-based, single-point commercial heating cable control system with integrated equipment ground-fault protection, BACnet gateway, dry contact alarm output, NEMA 4X fiber reinforced plastic enclosure, 120-277 V 30 A double pole relay.
 - 2.2.2 Manufacturers:
 - 2.2.2.1 Raychem Canada Ltd.;
 - 2.2.2.2 Dimplex/Chromalox Inc.;
 - 2.2.2.3 Tyco Thermal Controls/Pyrotenax.
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2.3 ELECTRIC SNOW MELTING CABLE

- 2.3.1 Raychem Canada Ltd. "ElectroMelt EM2-XR" CSA certified, parallel circuit construction, self-regulating cable consisting of 2 #14 gauge nickel coated copper bus wires embedded in a parallel self-regulating polymer core and covered by a crosslinked dielectric jacket, protected by a tinned-copper braid and a 70 mm (2-3/4") thick modified polyolefin outer jacket, and complete with "ElectroMelt EMK-XJB" junction boxes for power connections and end seal terminations. Additional accessories as follows:
 - 2.3.1.1 expansion joint kits to permit cable to cross heated surface expansion joints;
 - 2.3.1.2 splice kits to permit splicing or repairing cable;
 - 2.3.1.3 for each snow melting area, an anodised aluminium snow melting area caution sign for flush with grade installation.
 - 2.3.1.4 Complete with integral ground fault protection.
- 2.3.2 Manufacturers:
 - 2.3.2.1 Raychem Canada Ltd.;
 - 2.3.2.2 Dimplex/Chromalox Inc.;
 - 2.3.2.3 Tyco Thermal Controls/Pyrotenax.

2.4 SNOW MELTING CABLE CONTROL

- 2.4.1 Raychem Canada Ltd. components as follows:
 - 2.4.1.1 Model CIT-1, 24 VAC, roof or mast mounting, solid-state, microcontroller design aerial snow sensor to detect falling or blowing precipitation at 3.37°C (38°F) before snow or ice begins to accumulate;
 - 2.4.1.2 Model APS-4C surface wall mounting snow controller with contactor and integral 30 mA ground fault circuit interrupter, test/reset facility, a relay interface for connection to a building management system, and an adjustable high temperature sensor to protect heating cable from excessive temperature.
 - 2.4.1.3 Complete with integral ground fault protection.
- 2.4.2 Manufacturers:
 - 2.4.2.1 Raychem Canada Ltd.;
 - 2.4.2.2 Dimplex/Chromalox Inc.;
 - 2.4.2.3 Tyco Thermal Controls/Pyrotenax.

3 EXECUTION

3.1 INSTALLATION OF DOMESTIC WATER TEMPERATURE MAINTENANCE CABLE

- 3.1.1 Supply electric tracing cable sets to maintain temperature of domestic hot water piping.
- 3.1.2 Hand cable sets and accessories and cable manufacturer's installation instructions to electrical trade at site for installation on piping. Clearly identify piping to be traced. Ensure piping has been pressure tested prior to cable installation and manufacturer's installation instructions are observed.
- 3.1.3 After cable installation but before application of piping insulation, megger test and commission cable in presence of the Consultant and in accordance with cable manufacturer's installation and operation manual. Replace any damaged or faulty cable, and when satisfactory results have been obtained, submit signed test reports to the Consultant.
- 3.1.4 When traced piping has been insulated, install "Electrically Traced" labels on opposite sides of pipe at 3 m (10') intervals and in accordance with requirements specified in Section 20 05 00 – Common Work Results for Mechanical.

3.2 INSTALLATION OF FREEZE PROTECTION HEATING CABLE

- 3.2.1 Supply electric tracing cable sets to prevent piping from freezing.
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- 3.2.2 Hand cable sets and accessories and cable manufacturer's installation instructions to electrical trade at site for installation on piping. Clearly identify piping to be traced. Ensure piping has been pressure tested prior to cable installation and manufacturer's installation instructions are observed.
- 3.2.3 Mount heat tracing controller as indicated on drawings or within 2 m of start of heat tracing.
- 3.2.4 After cable installation but before application of piping insulation, megger test and commission cable in presence of the Consultant and in accordance with cable manufacturer's installation and operation manual. Replace any damaged or faulty cable, and when satisfactory results have been obtained, submit signed test reports to the Consultant.
- 3.2.5 When traced piping has been insulated, install "Electrically Traced" labels on opposite sides of pipe at 3 m (10') intervals and in accordance with requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
- 3.2.6 When cable installations are complete, check and test operation of each cable set with heater manufacturer's representative, make any required adjustments, and have cable manufacturer certify in writing that cable sets have been properly installed and operate as intended.

3.3 *INSTALLATION OF SNOW MELTING SYSTEM CABLE*

- 3.3.1 Supply electric heating cable to prevent ice and snow formation on exterior surfaces.
- 3.3.2 Hand cable and accessories and cable manufacturer's installation instructions to electrical trade at site for installation on the surfaces. Clearly identify areas to be heated. Ensure surfaces are cleaned and suitable for cable installation prior to cable installation, and manufacturer's installation instructions are observed.
- 3.3.3 Install snow sensor and connect to snow controller with 24 V wiring in conduit in accordance with sensor manufacturer's instructions and wiring standard of electrical work. Test operation of sensor and controller in presence of cable manufacturer's representative and adjust as required.
- 3.3.4 After cable installation but before placement of covering surface material, megger test and commission cable in presence of the Consultant and in accordance with cable manufacturer's installation and operation manual. Replace any damaged or faulty cable, and when satisfactory results have been obtained, submit signed test reports to the Consultant.
- 3.3.5 Carefully place an aluminium snow melting area caution sign flush with grade at each snow melting area, and coordinate placement with trade constructing finished surface.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 This Section specifies vibration isolation product requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.2 SUBMITTALS

- 1.2.1 Submit copies of manufacturer's product data sheets for products specified in this Section. Product data sheets are to include product characteristics, limitations, dimensions, finishes, and installation recommendations.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Submit a letter from vibration isolation manufacturer to certify correct installation of products, as specified in Part 3 of this Section.

1.4 SEISMIC RESTRAINT REQUIREMENTS

- 1.4.1 Where applicable to the project, for requirements for the use of a Seismic Consultant and seismic restraint requirements required for vibration isolated materials and equipment, refer to Section 20 05 48.16 – Seismic Controls for Mechanical Systems.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 Vibration isolation products are to be in accordance with the most recent edition of the ASHRAE Handbook and/or as indicated on drawings, schedules, details, and as specified below.
- 2.1.2 Springs are to be stable, colour coded, selected to operate at no greater than 2/3 solid load, designed in accordance with Society of Automotive Engineers Handbook Supplement 9 entitled Manual on Design and Application of Helical and Spiral Springs, and with spring diameters in accordance with manufacturer's recommendations to suit static deflection and maximum equipment load.
- 2.1.3 Steel components of isolation products not exposed to the weather or moisture are to be zinc plated. Steel components of isolation products exposed to the weather or in a damp, moist environment are to be factory painted with rust inhibiting primer and 2 coats of neoprene.
- 2.1.4 Where weight of isolated equipment may change significantly due to draining or filling with a liquid, vibration isolators are to be equipped with limit stops to limit spring extensions.
- 2.1.5 Seismic rated isolators and snubbers are to be listed, rated, and approved by State of California Office of Statewide Health and Planning Department (O.S.H.P.D.) and carry an O.S.H.P.D. pre-approved number. Seismic restraints supplied with vibration isolation are to meet requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 2.1.6 Flexible piping connections to vibration isolated equipment are specified in the appropriate piping sections of the Specification.

2.2 ISOLATION PADS

- 2.2.1 Sandwich type pads, 20 mm (¾") nominal thickness, selected for 3.2 mm (1/8") static deflection unless otherwise specified, consisting of 2 waffle type or ribbed 50 durometer
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neoprene pads permanently bonded to a minimum 10 gauge steel plate, and complete with rubber bushed bolt holes and equipment anchor bolts with neoprene isolation grommets.

2.2.2 Manufacturers:

- 2.2.2.1 Vibro-Acoustics Ltd. Type NSN;
- 2.2.2.2 The VMC Group Vibration Mounting & Controls Inc. (Korfund-Dynamics) "SHEAR-FLEX PLATES";
- 2.2.2.3 Kinetics Noise Control Vibron Products Group Type NGS/NGD;
- 2.2.2.4 Mason Industries Inc. Type SW/S/SW with HG Bolt Insertion Washers;
- 2.2.2.5 J. P. America Inc. Type JSJ.

2.3 RUBBER FLOOR ISOLATORS

2.3.1 Captive, bridge bearing quality neoprene mount selected for a minimum 4 mm (0.15") static deflection unless otherwise specified, with an integral ductile iron housing and integral equipment anchor bolt.

2.3.2 Manufacturers:

- 2.3.2.1 Vibro-Acoustics Ltd. Type R;
- 2.3.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type RSM;
- 2.3.2.3 Kinetics Noise Control Vibron Products Group Type RQ;
- 2.3.2.4 Mason Industries Inc. Type BR;
- 2.3.2.5 J. P. America Inc. Type TRM.

2.4 SPRING FLOOR ISOLATORS

2.4.1 Seismically rated captive spring mount isolator complete with levelling bolts, upper and lower neoprene spring cups, neoprene cushion, ductile iron housing, neoprene sound pads, and neoprene isolation grommets for securing bolts.

2.4.2 Manufacturers:

- 2.4.2.1 Vibro-Acoustics Ltd. Type SFS;
- 2.4.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type AMSR;
- 2.4.2.3 Kinetics Noise Control Vibron Products Group Type FLSS;
- 2.4.2.4 Mason Industries Inc. Type SSLFH;
- 2.4.2.5 J. P. America Inc. Type TSO-C-SC.

2.5 OPEN SPRING MOUNTS

2.5.1 Base mount free-standing assemblies, each complete with a stable colour coded steel spring welded in place, drilled mild steel mounting plate bonded to a ribbed rubber or neoprene acoustical pad, and an external 16 mm (5/8") diameter level adjustment bolt.

2.5.2 Manufacturers:

- 2.5.2.1 Vibro-Acoustics Ltd. Type FS;
- 2.5.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Type A;
- 2.5.2.3 Kinetics Noise Control Vibron Products Group Type FDS;
- 2.5.2.4 Mason Industries Inc. Type SLFH;
- 2.5.2.5 J. P. America Inc. Type TSO.

2.6 CLOSED SPRING MOUNTS

2.6.1 Base mount free-standing enclosed assemblies, each complete with stable colour coded spring(s), 2-piece cast housing, non-binding rubber horizontal stabilizers, a ribbed rubber or neoprene acoustical pad bonded to base of the closed housing, and an external level adjustment bolt.

2.6.2 Manufacturers:

- 2.6.2.1 Vibro-Acoustics Ltd. Type CM;
- 2.6.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Types B and C;
- 2.6.2.3 Kinetics Noise Control Vibron Products Group Type FLS;
- 2.6.2.4 Mason Industries Inc. Type C;
- 2.6.2.5 J. P. America Inc. Type TSC.

2.7 TOTALLY RETAINED SPRING MOUNTS

2.7.1 Base mount free-standing enclosed and retained assemblies to limit both vertical and lateral movement of mounted equipment, each complete with stable colour coded spring(s), drilled welded steel housing and top plate, ribbed rubber or neoprene acoustical pad bonded to bottom of housing, vertical limit adjusting hardware, and a level adjustment bolt.

2.7.2 Manufacturers:

- 2.7.2.1 Vibro-Acoustics Ltd. Type CSR;
- 2.7.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Type MS;
- 2.7.2.3 Kinetics Noise Control Vibron Products Group Type SM;
- 2.7.2.4 Mason Industries Inc. Type SLRSO;
- 2.7.2.5 J. P. America Inc. Type TSR.

2.8 SPRING HANGERS

2.8.1 Welded steel plate housing with top and bottom rod mounting holes and spring retainer, neoprene double deflection isolation element, stable colour coded spring, and heavy-duty rubber washers.

2.8.2 Manufacturers:

- 2.8.2.1 Vibro-Acoustics Ltd. Type SHR-SN;
- 2.8.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Series HRSA;
- 2.8.2.3 Kinetics Noise Control Vibron Products Group. Type SRH;
- 2.8.2.4 Mason Industries Inc. Type 30N;
- 2.8.2.5 J. P. America Inc. Type TSH.

2.9 NEOPRENE HANGER ISOLATORS

2.9.1 Neoprene double deflection rod isolators with steel housing and hanger rod bushing, selected for a minimum 4 mm (0.15") static deflection unless otherwise specified.

2.9.2 Manufacturers:

- 2.9.2.1 Vibro-Acoustics Ltd. Type NH;
- 2.9.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type HR;
- 2.9.2.3 Kinetics Noise Control Vibron Products Group Type RH;
- 2.9.2.4 Mason Industries Inc. Type HD or WHD;
- 2.9.2.5 J. P. America Inc. Type TRH.

2.10 CONCRETE INERTIA TYPE EQUIPMENT BASE

2.10.1 Welded steel bases, each complete with a structural black steel channel frame, concrete reinforcing rods, and brackets for spring mounts welded to frame.

2.10.2 Manufacturers:

- 2.10.2.1 Vibro-Acoustics Ltd. Type CIB;
 - 2.10.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type CPF;
 - 2.10.2.3 Kinetics Noise Control Vibron Products Group. Type CIB;
 - 2.10.2.4 Mason Industries Inc. Type KSL;
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2.10.2.5 J. P. America Inc. Type BCI.

2.11 STEEL EQUIPMENT BASE

- 2.11.1 Fully welded structural steel equipment and motor support bases, each complete with a wide flange steel frame, full depth cross members, brackets for spring mounts, and adjustable motor slide rails.
- 2.11.2 Manufacturers:
 - 2.11.2.1 Vibro-Acoustics Ltd. Type SB;
 - 2.11.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type WFB;
 - 2.11.2.3 Kinetics Noise Control Vibron Products Group Type SFB;
 - 2.11.2.4 Mason Industries Inc. Type WFSL;
 - 2.11.2.5 J. P. America Inc. Type BWS (with motor slide rail).

2.12 COMBINATION STEEL/CONCRETE INERTIA EQUIPMENT BASE

- 2.12.1 Welded steel bases with a structural black steel channel frame, concrete reinforcing rods, bottom sheet steel pan, brackets for spring mounts welded to frame and adjustable motor slide rails.
- 2.12.2 Manufacturers:
 - 2.12.2.1 Vibro-Acoustics Ltd. Type CIB (with motor slide rails);
 - 2.12.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type WPF (with motor slide rails);
 - 2.12.2.3 Kinetics Noise Control Vibron Products Group Type CIB (with motor slide rails);
 - 2.12.2.4 Mason Industries Inc. Type BMK or K;
 - 2.12.2.5 J. P. America Inc. Type BSI (with motor slide rail).

2.13 SLUNG STEEL BASE

- 2.13.1 Slung steel bases of structural members with gusset plates welded to ends and complete with adjustable motor slide rails and vertical section size to suit equipment's motor power output.
- 2.13.2 Manufacturers:
 - 2.13.2.1 Vibro-Acoustics Ltd. Type SS;
 - 2.13.2.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type CPF;
 - 2.13.2.3 Kinetics Noise Control Vibron Products Group Type CIB-H;
 - 2.13.2.4 Mason Industries Inc. Type MSL.

2.14 CONTINUOUS RAIL TYPE ISOLATION FOR ROOF MOUNTED EQUIPMENT

- 2.14.1 Continuous rooftop isolation shipped completely assembled, consisting of:
 - 2.14.1.1 galvanized steel sections formed to fit roof curb and associated equipment with a flexible air and weather seal joining upper and lower rail sections;
 - 2.14.1.2 stable springs, cadmium plated and selected to provide minimum deflection with 50% additional travel to solid;
 - 2.14.1.3 neoprene cushioned and wind restraints allowing 6 mm (¼") movement before engaging and resisting wind loads in any lateral direction.
 - 2.14.2 Manufacturers:
 - 2.14.2.1 Vibro-Acoustics Ltd. Vibro-Acoustics Type RTR;
 - 2.14.2.2 The VMC Group Vibration Mounting and Controls (Korfund-Dynamics) Type RTIR;
 - 2.14.2.3 Kinetics Noise Control Vibron Products Group Type KSR;
 - 2.14.2.4 Mason Industries Inc. Type RSC;
 - 2.14.2.5 J. P. America Inc. Type BRC.
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3 EXECUTION

3.1 *INSTALLATION OF VIBRATION ISOLATION MATERIALS*

- 3.1.1 Unless otherwise stated in the drawings, schedules and/or typical details, vibration isolation is to be provided for all mechanical equipment as per the recommendations contained within in the most recent edition of the ASHRAE Handbook.
 - 3.1.2 Supply to vibration isolation product manufacturer or supplier a copy of a "reviewed" shop drawing or product data sheet for each piece of equipment to be isolated and dimensioned pipe layouts of associated piping to be isolated.
 - 3.1.3 Unless otherwise specified, vibration isolation products are to be product of one manufacturer.
 - 3.1.4 Ensure vibration isolation manufacturer coordinates material selections with equipment provided in order to ensure adherence to performance criteria. Allow for expansion and contraction when material is selected and installed.
 - 3.1.5 Unless otherwise indicated, install isolation materials for base mounted equipment on concrete housekeeping pad bases which extend at least over the full base and isolated area of the isolated equipment. Additional requirements are as follows:
 - 3.1.5.1 block and shim bases level so ductwork and piping connections can be made to a rigid system at proper operating level, before isolated adjustment is made, and ensure there is no physical contact between isolated equipment and building structure;
 - 3.1.5.2 steel bases are to clear the sub-base by 25 mm (1");
 - 3.1.5.3 concrete bases are to clear the sub-base by 50 mm (2").
 - 3.1.6 Isolate piping larger than 25 mm (1") dia. directly connected to motorized and/or vibration isolated equipment with 25 mm (1") static deflection spring hangers at spacing intervals in accordance with following:
 - 3.1.6.1 for pipe less than or equal to 100 mm (4") dia. – first 3 points of support;
 - 3.1.6.2 for pipe 125 mm (5") to 200 mm (8") dia. – first 4 points of support;
 - 3.1.6.3 for pipe equal to or greater than 250 mm (10") dia. – first 6 points of support;
 - 3.1.7 First point of isolated piping support is to have a static deflection of twice the deflection of the isolated equipment but maximum 50 mm (2").
 - 3.1.8 Secure top of spring hanger frame rigidly to structure, and do not install spring hangers in concealed locations.
 - 3.1.9 Where it is impossible to use at least 2 spring hangers, provide Senior Flexonics Ltd. Style 102 (or 102-U as required) or equal, twin sphere, moulded rubber flexible connection assemblies, selected by manufacturer and suitable in all respects for intended application, and complete with required nipples and connections to provide proper vibration isolation.
 - 3.1.10 Isolate designated piping risers at floor support points in accordance with drawing detail and/or where indicated on drawings.
 - 3.1.11 Erect roof curb vibration isolation in accordance with instructions shipped with assembly. Match vibration isolation with associated roof top unit and orient isolation as identified by manufacturer to ensure proper loading and optimum performance. Caulk top of roof curb with 2 beads of caulking provided and centre isolation assembly onto roof curb and, unless otherwise noted, screw in place with 50 mm (2") lag screws at 900 mm (36") O.C. Position gasket on top rail or alternatively, caulk with 2 beads of caulking provided and orient and lower roof top unit onto isolation rails and, unless otherwise noted, screw unit into top rail with 25 mm (1") lag screws at 900 mm (36") O.C. After roof top unit is secured in place, but before damageable work is installed, spray each isolated equipment assembly with water and correct any water leaks.
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- 3.1.12 For control wiring connections to vibration isolated equipment ensure flexible metallic conduit with 90° bend is used for conduit 25 mm (1") dia. and smaller, and for conduit larger than 25 mm (1") dia., use Crouse Hinds EC couplings. Connections are to be long enough so that conduit will remain intact if equipment moves 300 mm (12") laterally from its installed position, and flexible enough to transmit less vibration to structure than is transmitted through vibration isolation. Coordinate these requirements with mechanical trades involved. If electrical power connections are not made in a similar manner as part of the electrical work, report this fact to the Consultant.
- 3.1.13 For requirements pertaining to seismically restrained vibration isolation, refer to Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.1.14 Arrange and pay for vibration isolation product manufacturer to visit site to inspect installation of his equipment. Perform revision work required as a result of improper installation. When vibration isolation equipment manufacturer is satisfied with the installation, obtain and submit a letter stating manufacturer has inspected the installation and equipment is properly installed.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 This Section specifies seismic control and restraint requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.2 SEISMIC CONSULTANT

- 1.2.1 Retain and pay for services of an experienced Seismic Consultant who is a registered professional engineer licensed in the jurisdiction of the work and a member in good standing of a Professional Engineers Association in the jurisdiction of the work.
- 1.2.2 Seismic Consultant is to:
 - 1.2.2.1 determine proper seismic hazard level, design, recommend, and review proposed mechanical work seismic restraint shop, placement and securing drawings, and sign and stamp drawings prior to submittal for review as specified below;
 - 1.2.2.2 supervise installation of mechanical work seismic restraint and, when work is complete, certify in writing that seismic restraint work has been installed in accordance with signed, stamped and reviewed drawings;
 - 1.2.2.3 prepare and submit to Municipality and authorities having jurisdiction, on a form approved by Municipality and authorities having jurisdiction, at the beginning of seismic restraint work and when work is complete, original signed and sealed Letters of Assurance for design, installation and field review of seismic restraint work.

1.3 SUBMITTALS

- 1.3.1 Obtain required equipment information and submit manufacturer's shop drawings/product data sheets for restraining devices and steel bases. Include placement data, and details of attachment to both equipment and structure meeting requirements of forces involved. Product data sheets and drawings are to be signed and stamped by Seismic Consultant referred to above.
- 1.3.2 If requested, submit samples of seismic restraint materials for review.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Submit copies of Seismic Consultant's Letters of Assurance as specified above.
- 1.4.2 Submit copies of Seismic Consultant and seismic control manufacturer's certification letters as specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

- 1.5.1 Seismic restraints are to be designed by a registered professional engineer as specified above, and are to be installed by qualified tradesmen under supervision of and to the approval of the design engineer.
 - 1.5.2 Unless otherwise specified, seismic control and restraints are to be designed in accordance with Code requirements, ANSI/SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, SMACNA/ASHRAE Service Restraint Applications CD-ROM, and the P.P.I.C. Manual Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems, all of which are to form a part of this Section.
 - 1.5.3 Seismic control and restraints for fire protection piping and equipment are to be in accordance with NFPA requirements. When specified and/or required, design is also to include Factory Mutual requirements.
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- 1.5.4 Restraint products must be tested in an independent testing laboratory, or certified by Seismic Consultant, to confirm restraint products meet requirements of this Section, i.e. dynamic ultimate limit load state as required by Code, "Fail Safe" design, etc. If particular tests are carried out to represent a restraint type, test is to be valid for the full load range of the restraint. Submit such tests or certification when requested.
- 1.5.5 Seismic control and restraint product manufacturers are to provide required assistance during installation, and, when installation is complete, submit written reports listing any deficiencies to the installation.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 Isolation, anchors, bolts, bases, restraints, etc., are to be designed to withstand without failure or yielding, the dynamic G load as specified in Code for the seismic zone in which building is located. Design loads are ultimate limit state loads (1.5 times working load) acting through the centre of gravity of the anchored or restrained equipment. "Fail Safe" designs are acceptable.
- 2.1.2 For both isolated and non-isolated floor mounted equipment, i.e. tanks, heat exchangers, boilers, etc., design and provide anchors and bolts to withstand, without failure or yielding, a dynamic ultimate limit state load as defined in Code, of the greater of 0.3 g or as required by Code, applied horizontally through the centre of gravity.
- 2.1.3 Where impact forces may be significant, use ductile materials.
- 2.1.4 Seismic restraining devices factory supplied with equipment are to meet requirements of this Section.

2.2 MANUFACTURERS

- 2.2.1 Mason Industries Inc.;
- 2.2.2 Kinetics Noise Control;
- 2.2.3 Vibro-Acoustics Ltd;
- 2.2.4 Price Industries Inc.

2.3 SLACK CABLE RESTRAINTS

- 2.3.1 Aircraft cable galvanized slack cable restraints meeting current requirements of Building Code, sized to suit the application and complete with required cable ties, anchor hardware (selected for a load equal to twice the weight of the equipment), and similar connection accessories.

2.4 ANCHOR BOLTS

- 2.4.1 Equal to Mason Industries type SAB seismic anchor bolts.

2.5 FLEXIBLE PIPING CONNECTIONS

- 2.5.1 Flexible piping connectors are to be supplied with seismic restraint materials. Where flexible connections are not specified with piping in other Sections they are to be equal to Mason Industries twin sphere, non-metallic connectors with hose lengths preset in strict accordance with manufacturer's instructions and to approval of Seismic Consultant, each rated for continuous operation at 1725 kPa at 87.7°C (250 psi at 190°F) or 1380 kPa at 121°C (200 psi at 250°F), and complete with:
 - 2.5.1.1 nylon tire cord reinforced EPDM body;
 - 2.5.1.2 ductile iron reinforcing ring and ductile iron screwed or flanged connections as required and to suit piping system operating pressure.

2.6 VIBRATION ISOLATION PRODUCTS

2.6.1 Refer to Section 20 05 48.13 – Vibration Controls for Mechanical Systems.

3 EXECUTION

3.1 INSTALLATION OF SEISMIC RESTRAINT MATERIALS

- 3.1.1 Provide seismic restraint for mechanical equipment, piping, and ductwork, including diffusers, grilles, etc., as per requirements of current edition of Building Code and this Section of the Specification.
- 3.1.2 Following Mechanical Components Restraint Guide is to be used as a general guide only to establish appropriate restraint methods, hardware, and attachments, however, due to differences in construction, size, weight, and configuration of different manufacturer's equipment and variety of ways and means that equipment and components can be installed, specific restraint methods are to be confirmed in the field. Seismic restraint materials and methods are to be reviewed and approved by Seismic Consultant.
- 3.1.3 Mechanical Component Restraint Guide:

Item	Type of Restraint	Minimum no. of Restraints	Notes
In-line Pumps	SCR	2	Pipe mounted type pump
Pumps Non-Isolated	BTHP	4	Base mount type pump
Pumps Isolated	SNBR	4	Base mount type pump
Expansion Tanks	SCR	4	
D.H.W. Tanks	SCR	4	Attach to removable steel strap yoke
Glycol Tanks	SCR	4	Attach to removable steel strap yoke
Boilers			
- With Base	BTHP	4	
- Without Base	CSSB	4	
Chillers			
- Isolated	SNBR	4	
- Non-Isolated	BTHP	4	
Cooling Towers Closed Circuit Coolers			
- Isolated	SNBR	4	
- Non-Isolated	BTSLPR	4	
Heat Exchangers	BTHP	4	Bolt to custom support frame
Radiant Panels	SCR	4	Per panel section
Unit Heaters	TSR-SCR	4	
Force Flow Heaters	TSR-SCR	4	

<u>Item</u>	<u>Type of Restraint</u>	<u>Minimum no. of Restraints</u>	<u>Notes</u>
AHU's and A/C Units Free Standing			
- With Base	BTHP	4	
- Without base	CSSB	4	
AHU's and A/C Units Suspended			
- Isolated	SCR	4	
- Non-Isolated	SCR	4	
Packaged Rooftop Air Units (all types)			
On roof curb	BTRC	4	Roof curb bolted to roof.
Humidifiers	BTHP	4	Bolt unit to custom stand.
Electronic		4	Bolt stand to housekeeping pad or structure.
Fans – Suspended			
- Isolated	SCR	4	
- Non-Isolated	SCR	4	
Fans – Freestanding			
- Isolated	SNBR	4	
- Non-Isolated	BTHP	4	
Grilles, Registers, Diffusers	SCR	4	Where not bolted to duct (i.e. in tee-bar ceilings)
Airflow Control Valves	SCR	4	Where suspended
Air Compressor Receiver Sets			
- Isolated	BTHP	4	
- Non-Isolated			
Piping	SCR TSR	As required	As per Specification
Ductwork	SCR TSR	As required	As per Specification

3.1.4 Legend

Legend	
SCR	Slack cable restraint (bolted to structure)
SNBR	Seismic snubber (bolted to structure)
TSR	Threaded support rod (bolted or clamped to structure)
BTSLPR	Bolt to sleeper (sleeper bolted to structure)
BTHP	Bolt to concrete housekeeping pad (pad to be keyed to structure)
CSSB	Custom steel shoe base (bolted to structure)
BTRC	Bolt to roof curb (roof curb bolted to roof structure)

- 3.1.5 Provide structural steel bases for equipment unless equipment manufacturer certifies direct attachment capabilities.
- 3.1.6 Space restraints under equipment so minimum distance between adjacent corner restraints is at least equal to the height of the centre of gravity of the equipment. Include the height of the centre of gravity on shop drawings, otherwise, design for increased forces on supports and submit design calculations with shop drawings. In particular, chillers are to meet this requirement.
- 3.1.7 Floor mounted isolated equipment is to be installed on 100 mm (4") high concrete housekeeping pads with at least 200 mm (8") clearance between drilled inserts and edges of pads. Ensure housekeeping pads are keyed to structure to resist seismic displacement.
- 3.1.8 Requirements pertaining to seismic control work are as follows:
- 3.1.8.1 execute seismic control and restraint work in accordance with drawing details, reviewed shop drawings, ANSI/SMACNA Seismic Restraint Manual, PIPC Manual: Guidelines for Seismic Restraints of Mechanical Systems and Plumbing Piping Systems, and National Uniform Seismic Installation Guidelines (NUSIG);
 - 3.1.8.2 seismic control systems are to work in all directions;
 - 3.1.8.3 fasteners and attachment points are to resist same maximum load as the seismic restraint;
 - 3.1.8.4 drilled or power driven anchors and fasteners are not permitted;
 - 3.1.8.5 no equipment, equipment supports or mounts are to fail before failure of structure;
 - 3.1.8.6 supports of cast iron or threaded pipe are not permitted;
 - 3.1.8.7 seismic control measures are not to interfere with integrity of firestopping;
 - 3.1.8.8 equipment is to be bolted to structure, and bolts are to be fitted with isolation washers;
 - 3.1.8.9 number, size, type, and installation of anchor bolts are to be as recommended by anchor bolt manufacturer and seismic design consultant;
 - 3.1.8.10 where more than a 3 mm (1/8") differential exists between an anchor or attachment bolt diameter, an anchor and attachment point hole, or an isolator gap attachment bolt and equipment anchor attachment hole, pack air gap with Mason type 0.5 FastSteel reinforced epoxy putty;
 - 3.1.8.11 hung equipment and pipe hangers are to be fitted with a means of preventing upward movement, and non-isolated equipment and pipe hanger rods are to be fitted with oversized steel washers and nuts above and below hanger or equipment attachment point, locked tight to prevent uplift of equipment or hanger;

- 3.1.8.12 where suspended equipment hanger rod length exceeds 50 rod diameters between structure and equipment attachment point, reinforce rods with angle iron to prevent bending due to uplift forces;
 - 3.1.8.13 seismic control measures are not to jeopardize noise and vibration isolation systems, and 6 mm (¼") to 9 mm (3/8") clearance during normal operation of equipment and systems is to be provided between seismic restraint and equipment;
 - 3.1.8.14 where hold-down bolts for seismic restraint equipment penetrate roofing membranes coordinate with roofing trade for installation of pitch pockets/"gum cups" and sealing compound to maintain water-tight integrity of roof;
 - 3.1.8.15 where friction type clamps are used for support of equipment and connecting services, secure clamps to steel work by means of welding or other positive means to prevent slippage or loosening of clamps due to seismic forces.
 - 3.1.9 Provide slack cable restraint assemblies for:
 - 3.1.9.1 steam piping 32 mm (1-¼") dia. and larger;
 - 3.1.9.2 fuel gas, fuel oil, medical gas, compressed air and service piping 25 mm (1") dia. and larger;
 - 3.1.9.3 piping 32 mm (1-¼") dia. and larger located in boiler, fan, chiller, and similar equipment rooms;
 - 3.1.9.4 horizontal and vertical piping 65 mm (2-½") dia. and larger;
 - 3.1.9.5 ductwork and duct mounted equipment;
 - 3.1.9.6 isolated and non-isolated ceiling hung fans, tanks, equipment, etc.;
 - 3.1.9.7 generator exhaust system(s).
 - 3.1.10 Installation requirements for slack cable restraints include following:
 - 3.1.10.1 connect slack cable restraints to ceiling hung equipment in such a way that axial projection of wires passes through the centre of gravity of the equipment;
 - 3.1.10.2 orient restraint wires on ceiling hung equipment at approximately 90° to each other (in plan), and tie back to the ceiling slab at an angle not exceeding 45° to slab;
 - 3.1.10.3 install cables using appropriate grommets, shackles, and other hardware to ensure alignment of restraints and to avoid bending cables at connection points, and, where feasible, wrap cables directly around pipes as opposed to using collars;
 - 3.1.10.4 for piping systems, provide transverse slack cable restraints at a maximum spacing of 12.5 m (40'), and longitudinal restraints at 25 m (80') maximum spacing, or as limited by anchor/slack cable performance;
 - 3.1.10.5 for piping less than 250 mm (10") dia., reduce transverse restraint spacing to 6 m (20'), and note that smaller piping may be rigidly tied to larger piping for restraint, but not the reverse;
 - 3.1.10.6 vary adjacent spacing of restraints on a piping run by 10% to 30% to avoid coincident resonance;
 - 3.1.10.7 transverse bracing for one pipe section may also act as longitudinal bracing for piping connected perpendicular to it if bracing is installed within 600 mm (24") of elbow or tee, and if connected piping is same or smaller dia., and note that branch lines are not to be used to restrain main lines;
 - 3.1.10.8 provide flexibility in piping joints or sleeves where piping penetrates building seismic or expansion joints;
 - 3.1.10.9 wherever possible, support weight of vertical piping risers at a point or points above the centre of gravity of riser, and provide lateral guides at top and bottom of riser, and at intermediate points not to exceed the transverse spacing specified above for horizontal pipes, with guide clearance not exceeding 3 m (10');
 - 3.1.10.10 install restraints at least 50 mm (2") clear of other equipment and services;
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- 3.1.10.11 adjust restraint cables such that they are not visibly slack, or such that flexibility is approximately 40 mm (1-½") under thumb pressure for a 1.5 m (5') cable length, with an equivalent ratio for other cable lengths, and adjust clearance of cable strap/spacer piece restraints so as not to exceed 6 mm (0.23");
- 3.1.10.12 provide transverse and axial restraints within 4 m (12') of a vertical bend;
- 3.1.10.13 at steel trusses, connect to top chords at panel points and follow truss manufacturer's instructions;
- 3.1.10.14 diffusers and grilles mounted in t-bar ceilings or which are not positively secured to ductwork or structure are to be fitted with slack cable restraints to prevent them from falling in the event the ceiling t-bar grid is displaced;
- 3.1.10.15 do not bridge vibration isolators with slack cable restraints;
- 3.1.10.16 other approved restraint systems are conventional pipe guides, rigid restraint where piping passes through a block or concrete wall, or a cable strap and spacer piece attached to structure and used where piping is adjacent to a wall and conventional slack cable restraints cannot be used.

3.2 *INSTALLATION OF FLEXIBLE PIPING CONNECTORS*

- 3.2.1 Supply flexible piping connectors for connections (including plumbing) to seismically restrained equipment. Hand connectors to appropriate piping trade at site for installation.

3.3 *SITE INSPECTION AND LETTERS OF CERTIFICATION*

- 3.3.1 When seismic control products have been installed, arrange for seismic control product manufacturer and Seismic Consultant to examine installation of seismic control products and to certify in writing (separate letters) that products have been properly installed in accordance with governing Codes and Regulations, and recommendations and instructions. Seismic Consultant is to apply his professional stamp to the letter.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Nameplates.
- 1.1.2 Tags.
- 1.1.3 Pipe Markers.

1.2 REFERENCES

- 1.2.1 ASME A13.1 – Scheme for the Identification of Piping Systems.

1.3 SUBMITTALS

- 1.3.1 Section 01 33 00: Submittals.
- 1.3.2 Submit list of wording, symbols, letter size, and colour coding for mechanical identification.
- 1.3.3 Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- 1.3.4 Product Data: Provide manufacturers catalogue literature for each product required.
- 1.3.5 Samples: Submit two labels, tags samples to Consultant for approval.
- 1.3.6 Manufacturer's Installation Instructions: Indicate special procedures, and installation.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Section 01 77 00: Project Closeout.
- 1.4.2 Record actual locations of tagged valves.

2 PRODUCTS

2.1 MECHANICAL WORK IDENTIFICATION MATERIALS

- 2.1.1 Confirm with the Owner if an existing mechanical work identification system is in place and, if so, match accordingly.
- 2.1.2 If an existing mechanical work identification system is not in place, the following is to be used:
 - 2.1.2.1 Equipment nameplates are to be minimum 1.6 mm (1/16") thick 2-ply laminated coloured plastic plates, minimum 12 mm x 50 mm (½" x 2") for smaller items such as damper motors and control valves, minimum 25 mm x 65 mm (1" x 2-½") for equipment, and minimum 50 mm x 100 mm (2" x 4") for control panels and similar items. Additional requirements are as follows:
 - (1) unless otherwise specified or required, each nameplate is to be white, complete with bevelled edges and black engraved wording to completely identify equipment and its use with no abbreviations;
 - (2) wording is generally to be as per drawings, i.e. Fan EF-1, and is to include equipment service and building area/zone served, but must be reviewed prior to engraving;
 - (3) supply stainless steel screws for securing nameplates in place;
 - (4) nameplates for equipment suspended above floor level or generally not within easy viewing from floor level are to be increased in size so as to be easily readable from floor level.

- 2.1.2.2 Valve tags are to be coloured, 40 mm (1-½") square, 2-ply laminated plastic with bevelled edges, red-white, green-white, yellow-black, etc., to match piping identification colour, each complete with a 3.2 mm (1/8") diameter by 100 mm (4") long brass plated steel bead chain, and four lines of engraved maximum size identification wording, i.e.:

VALVE V12 200 mm (8") CHILL. WATER NORMALLY OPEN

- 2.1.2.3 Standard pipe identification is to be equal to Smillie McAdams Summerlin Ltd., Brady or Primark Manufacturing Inc. vinyl plastic with indoor/outdoor type vinyl ink lettering and directional arrows, as follows:
- (1) for pipe less than or equal to 150 mm (6") diameter, coiled type snap-on markers of a length to wrap completely around pipe or pipe insulation;
 - (2) for pipe larger than 150 mm (6") diameter, saddle type strap-on markers with 2 opposite identification locations and complete with nylon cable ties.
- 2.1.2.4 Identification wording and colours for pipe identification materials are to be as follows:

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
domestic cold water	green	DOM. COLD WATER
domestic hot water supply	green	DOM. HW SUPPLY
domestic hot water recirculation	green	DOM. HW RECIRC.
tempered domestic water	green	TEMP. DOM. WATER
chilled drinking water	green	CH. DRINK WTR.
storm drainage	green	STORM
sanitary drainage	green	SAN.
plumbing vent	green	SAN. VENT
acid sanitary drainage	yellow	ACID DRAIN
acid drainage vent	yellow	ACID VENT
fire protection standpipe	red	F.P. STANDPIPE
fire protection sprinklers	red	F.P. SPRINKLER
natural gas	to Code	to Code, c/w pressure
natural gas vent	to Code	to Code
propane gas	to Code	to Code, c/w pressure
propane gas vent	to Code	to Code
fuel oil supply	yellow	FUEL OIL SUPPLY

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
fuel oil return	yellow	FUEL OIL RETURN
fuel oil vent	yellow	FUEL OIL VENT
heating water supply	yellow	HTG. WTR. SUPPLY
heating water return	yellow	HTG. WTR. RETURN
heating water drain	yellow	HTG. WTR. DRAIN
glycol heating supply	yellow	GLY. HTG. SUPPLY
glycol heating return	yellow	GLY. HTG. RETURN
glycol heating drain	yellow	GLY. HTG. DRAIN
glycol heat reclaim return	yellow	GLY. HTG. RECLAIM R.
glycol heat reclaim supply	yellow	GLY. HTG. RECLAIM S.
heat pump geothermal loop – source side supply	green	GEO. LOOP SOURCE SUPPLY
heat pump geothermal loop – source side return	green	GEO. LOOP SOURCE RETURN
heat pump geothermal loop – load side supply	green	GEO. LOOP LOAD SUPPLY
Heat pump geothermal loop – load side return	green	GEO. LOOP LOAD RETURN
condenser water supply	green	COND. WTR. SUPPLY
condenser water return	green	COND. WTR. RETURN
chilled water supply	green	CH. WTR. SUPPLY
chilled water return	green	CH. WTR. RETURN
chilled water drain	green	CH. WTR. DRAIN
low pressure steam	yellowkPa STEAM
medium pressure steam	yellowkPa STEAM
high pressure steam	yellowkPa STEAM
low pressure condensate	yellow	L.P. CONDENSATE
medium pressure condensate	yellow	M.P. CONDENSATE
high pressure condensate	yellow	H.P. CONDENSATE
pumped condensate	yellow	PUMPED CONDENSATE
steam vent	yellow	STEAM VENT
boiler feedwater	yellow	BLR. FEEDWATER
boiler blowdown	yellow	BLR. BLOW-OFF
refrigerant suction	yellow	REFRIG. SUCTION

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
refrigerant liquid	yellow	REFRIG. LIQUID
refrigerant hot gas	yellow	REFRIG. HOT GAS
diesel engine exhaust	yellow	ENGINE EXHAUST
gasoline	yellow	GASOLINE
distilled water	green	DISTILL. WATER
demineralized water	green	DEMIN. WATER
compressed air (< 700 kPa)	greenkPa COMP. AIR
compressed air (>700 kPa)	yellowkPa COMP. AIR
control air	green	CONTROL AIR

2.1.2.5 Colours for pipe identification legends and directional arrows are to be as follows:

IDENTIFICATION COLOUR	LEGEND & ARROW COLOUR
yellow	black
green	white
red	white

2.1.2.6 Duct identification is to be custom made Mylar stencils with 50 mm (2") high lettering to accurately describe duct service, i.e. "AHU-1 SUPPLY", complete with a directional arrow, and coloured ink with ink pads and roller applicators. Ink colour is generally to be black but must contrast with lettering background.

3 EXECUTION

3.1 PREPARATION

3.1.1 Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

3.2.1 Identify new exposed piping and ductwork as per Part 2 of this Section in locations as follows:

- 3.2.1.1 at every end of every piping or duct run;
- 3.2.1.2 adjacent to each valve, strainer, damper and similar accessory;
- 3.2.1.3 at each piece of connecting equipment;
- 3.2.1.4 on both sides of every pipe and duct passing through a floor, wall or partition, unless otherwise specified;
- 3.2.1.5 at 6 m (20') intervals on pipe and duct runs exceeding 6 m (20') in length;
- 3.2.1.6 at least once in each room, and at least once on pipe and duct runs less than 6 m (20') in length.

3.2.2 Unless otherwise specified identify new concealed piping and ductwork as per Part 2 of this Section in locations as follows:

- 3.2.2.1 at points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;
- 3.2.2.2 at maximum 6 m (20') intervals on piping and ductwork above suspended accessible ceilings, and at least once in each room;

- 3.2.2.3 at each access door location;
- 3.2.2.4 at each piece of connected equipment, automatic valve, etc.
- 3.2.3 Provide an identification nameplate for equipment provided as part of this project, including items such as control valves, motorized dampers, instruments, and similar products. Secure nameplates in place, approximately at eye level if possible, with stainless steel screws unless such a practice is prohibitive, in which case use epoxy cement applied to cleaned surfaces. Locate nameplates in the most conspicuous and readable location.
- 3.2.4 Paint new natural and/or propane gas piping with primer and 2 coats of yellow paint in accordance with Code requirements. Identify piping at intervals as specified above.
- 3.2.5 Provide an identification nameplate for each motor starter or disconnect switch located in a motor control centre or on a motor starter panel, and on each individually mounted starter provided as part of mechanical work, and on each disconnect switch provided as part of the electrical work for motorized equipment provided as part of mechanical work.
- 3.2.6 For electrically traced mechanical work, identification wording is to include "ELECTRICALLY TRACED".
- 3.2.7 Tag valves and prepare a valve tag chart in accordance with following requirements:
 - 3.2.7.1 attach a valve tag to each new valve, except for valves located immediately at equipment they control;
 - 3.2.7.2 prepare a digital valve tag chart to list tagged valves, with, for each valve, the tag number, location, valve size, piping service, and valve attitude (normally open or normally closed);
 - 3.2.7.3 if an existing valve tag chart is available at site, valve tag numbering is to be an extension of existing numbering and new valve tag chart is to incorporate existing chart;
 - 3.2.7.4 include a copy of valve tag chart in each copy of operating and maintenance instruction manuals.
- 3.2.8 Where shut-off valves, control dampers, sensors, and similar items which will or may need maintenance and/or repair are located above accessible suspended ceilings, provide round coloured ceiling tacks in ceiling panel material, or stickers equal to Brady "Quick Dot" on ceiling grid material to indicate locations of items. Unless otherwise specified, ceiling tack or sticker colours are to be as follows:
 - 3.2.8.1 HVAC piping valves and equipment: yellow
 - 3.2.8.2 fire protection valves and equipment: red
 - 3.2.8.3 plumbing valves and equipment: green
 - 3.2.8.4 HVAC ductwork dampers and equipment: blue
 - 3.2.8.5 control system hardware and equipment: orange

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 This Section specifies mechanical system testing, adjusting, and balancing requirements that are common to mechanical work Sections of the Specification and it is a supplement to each Section and is to be read accordingly.

1.2 DEFINITIONS

- 1.2.1 "Agency" – means agency to perform testing, adjusting and balancing work.
- 1.2.2 "TAB" – means testing, adjusting, and balancing to determine and confirm quantitative performance of equipment and systems and to regulate specified fluid flow rate and air patterns at terminal equipment, e.g., reduce fan speed, throttling, etc.
- 1.2.3 "hydronic systems" – includes heating water, chilled water, glycol-water solution, condenser water, and any similar system.
- 1.2.4 "air systems" – includes outside air, supply air, return air, exhaust air, and relief air systems.
- 1.2.5 "flow rate tolerance" – means allowable percentage variation, minus to plus, of actual flow rate values in Contract Documents.
- 1.2.6 "report forms" – means test data sheets arranged for collecting test data in logical order for submission and review, and these forms, when reviewed and accepted, should also form permanent record to be used as basis for required future testing, adjusting and balancing.
- 1.2.7 "terminal" – means point where controlled fluid enters or leaves the distribution system, and these are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.
- 1.2.8 "main" – means duct or pipe containing system's major or entire fluid flow.
- 1.2.9 "submain" – means duct or pipe containing part of the systems' capacity and serving 2 or more branch mains.
- 1.2.10 "branch main" – means duct or pipe servicing 2 or more terminals.
- 1.2.11 "branch" – means duct or pipe serving a single terminal.

1.3 SUBMITTALS

- 1.3.1 Within 30 days of work commencing at site, submit name and qualifications of proposed testing and balancing agency in accordance with requirements of article entitled Quality Assurance below.
- 1.3.2 Submit sample test forms, if other than those standard forms prepared by Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB), are proposed for use.
- 1.3.3 Submit a report by Agency to indicate Agency's evaluation of mechanical drawings with respect to service routing and location or lack of balancing devices. Include set of drawings used and marked-up by Agency to prepare report.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Submit a report by Agency after each site visit made by Agency during construction phase of this Project.
 - 1.4.2 Submit a draft report, as specified in Part 3 of this Section.
 - 1.4.3 Submit a final report, as specified in Part 3 of this Section.
 - 1.4.4 Submit a testing and balancing warranty as specified in Part 3 of this Section.
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- 1.4.5 Submit reports listing observations and results of post construction site visits as specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

- 1.5.1 Employ services of an independent testing, adjusting, and balancing agency meeting qualifications specified below, to be single source of responsibility to test, adjust, and balance building mechanical systems to produce design objectives. Agency is to have successfully completed testing, adjusting, and balancing of mechanical systems for a minimum of 5 projects similar to this Project within past 3 years, and is to be certified as an independent agency in required categories by one of following:
 - 1.5.1.1 AABC – Associated Air Balance Council;
 - 1.5.1.2 NEBB – National Environmental Balancing Bureau.
- 1.5.2 NBCTA certification in lieu of the above noted organizations is not permitted.
- 1.5.3 Testing, adjusting, and balancing of complete mechanical systems is to be performed over entire operating range of each system in accordance with 1 of following publications:
 - 1.5.3.1 National Standards for a Total System Balance published by Associated Air Balance Council;
 - 1.5.3.2 Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems published by National Environmental Balancing Bureau;
 - 1.5.3.3 Chapter 37, Testing, Adjusting, and Balancing of ASHRAE Handbook HVAC Applications.

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 SCOPE OF WORK

- 3.1.1 Perform total mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of fluid quantities of mechanical systems as required to meet design specifications and comfort conditions, and recording and reporting results.
- 3.1.2 Mechanical systems to be tested, adjusted, and balanced include:
 - 3.1.2.1 TAB of domestic water systems (all piping extended from Municipal main) is to include:
 - (1) domestic hot water recirculation piping;
 - (2) tempered water piping flows.
 - 3.1.2.2 TAB of swimming pool systems is to include all pool piping water flows.
 - 3.1.2.3 TAB of laboratory systems is to include flows through piping, fittings including bench work fittings, and associated equipment including special ventilation systems.
 - 3.1.2.4 TAB of medical gas systems is not part of TAB work and is specified in Section entitled Medical Gas Piping Systems.
 - 3.1.2.5 TAB of fuel oil system is to include supply and return oil flows as applicable, and is to be in accordance with requirements of CAN/CSA B139.
 - 3.1.2.6 TAB of heating systems is to include piping and equipment fluid temperatures, flows and control, and if TAB is not done during heating season, a follow-up site visit during heating season will be required to confirm proper flows and temperatures, and any required system "fine tuning".
 - 3.1.2.7 TAB of cooling systems is also to include piping and equipment fluid temperatures, flows and control, and if TAB is not done during cooling season,

- a follow-up site visit during cooling season will be required to confirm proper flows and temperatures, and any required system "fine tuning".
- 3.1.2.8 TAB of air handling systems is to include equipment and ductwork air temperatures, capacities and flows.

3.2 TESTING, ADJUSTING, AND BALANCING

- 3.2.1 Conform to following:
- 3.2.1.1 as soon as possible after award of Contract, Agency is to carefully examine a set of mechanical drawings with respect to routing of services and location of balancing devices, and is to issue a report listing results of the evaluation;
 - 3.2.1.2 set of drawings examined by Agency is to be returned with evaluation report, with red line mark-ups to indicate locations for duct system test plugs, and required revision work such as relocation of balancing devices and locations for additional devices;
 - 3.2.1.3 after review of mechanical work drawings and specification, Agency is to visit site at frequent, regular intervals during construction of mechanical systems, to observe routing of services, locations of testing and balancing devices, workmanship, and anything else that will affect testing, adjusting and balancing;
 - 3.2.1.4 after each site visit, Agency is to report results of site visit indicating date and time of visit, and detailed recommendations for any corrective work required to ensure proper adjusting and balancing;
 - 3.2.1.5 testing, adjusting and balancing is not to begin until:
 - (1) building construction work is substantially complete and doors have been installed;
 - (2) mechanical systems are complete in all respects, and have been checked, started, adjusted, and then successfully performance tested.
 - 3.2.1.6 mechanical systems to be tested, adjusted and balanced are to be maintained in full, normal operation during each day of testing, adjusting and balancing;
 - 3.2.1.7 obtain copies of reviewed shop drawings of applicable mechanical plant equipment and terminals, and temperature control diagrams and sequences;
 - 3.2.1.8 Agency is to walk each system from system "head end" equipment to terminal units to determine variations of installation from design, and system installation trades will accompany Agency;
 - 3.2.1.9 Agency is to check valves and dampers for correct and locked position, and temperature control systems for completeness of installation before starting equipment;
 - 3.2.1.10 wherever possible, Agency is to lock balancing devices in place at proper setting, and permanently mark settings on devices;
 - 3.2.1.11 Agency is to leak test ductwork as specified in Section entitled HVAC Air Distribution in accordance with requirements of SMACNA "HVAC Air Duct Leak Test Manual", coordinate work with work of aforementioned Sections, provide detailed sketch(es) to Sheet Metal Contractor and Consultant identifying ductwork not in accordance with acceptable leakage values specified in aforementioned Sections, and retest corrected ductwork;
 - 3.2.1.12 Agency is to balance systems with due regard to objectionable noise which is to be a factor when adjusting fan speeds and performing terminal work such as adjusting air quantities, and should objectionable noise occur at design conditions, Agency is to immediately report problem and submit data, including sound readings, to permit an accurate assessment of noise problem to be made;
 - 3.2.1.13 Agency is to check supply air handling system mixing plenums for stratification, and where variation of mixed air temperature across coils is found to be in
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- excess of $\pm 5\%$ of design requirements, Agency is to report problem and issue a detail sketch of plenum baffle(s) required to eliminate stratification;
- 3.2.1.14 Agency is to perform testing, adjusting and balancing to within $\pm 5\%$ of design values, and make and record measurements which are within $\pm 2\%$ of actual values;
- 3.2.1.15 for air handling systems equipped with air filters, test and balance systems with simulated 50% loaded (dirty) filters by providing a false pressure drop;
- 3.2.1.16 test, adjust and balance air conditioning systems during summer season and heating systems during winter season, including at least a period of operation at outside conditions within 2.8°C (5°F) wet bulb temperature of maximum summer design condition, and within 5.5°C (10°C) dry bulb temperature of minimum winter design condition, and take final temperature readings during seasonal operation.
- 3.2.2 Prepare reports as indicated below.
- 3.2.2.1 Upon completion of testing, adjusting, and balancing procedures, prepare draft reports on AABC or NEBB forms. Draft reports may be hand written, but must be complete, factual, accurate, and legible. Organize and format draft reports in same manner specified for final reports and submit for review.
- 3.2.2.2 Upon verification and approval of draft reports, prepare final reports organized and formatted as specified below. Use units of measurement (SI or Imperial) as used on Project Documents.
- 3.2.2.3 Report forms are to be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Report forms complete with schematic systems diagrams and other data are to be consolidated in electronic format as a PDF. PDF file to be indexed and organized into sections, as it applies to the project, as follows:
- (1) General Information and Summary;
 - (2) Air Systems;
 - (3) Hydronic Systems;
 - (4) Temperature Control Systems;
 - (5) Special Systems.
- 3.2.2.4 Agency is to provide following minimum information, forms and data in report:
- (1) inside cover sheet to identify Agency, Contractor, and Project, including addresses, and contact names and telephone numbers and a listing of instrumentation used for procedures along with proof of calibration;
 - (2) remainder of report is to contain appropriate forms containing as a minimum, information indicated on standard AABC or NEBB report forms prepared for each respective item and system;
 - (3) Agency is to include for each system to be tested, adjusted and balanced, a neatly drawn, identified (system designation, plant equipment location, and area served) schematic "as-built" diagram indicating and identifying equipment, terminals, and accessories;
 - (4) Agency is to include report sheets indicating building comfort test readings for all rooms.
- 3.2.3 After final testing and balancing report has been submitted, Agency is to visit site with Contractor and Consultant to spot check results indicated on balancing report. Agency is to supply labour, ladders, and instruments to complete spot checks. If results of spot checks do not, on a consistent basis, agree with final report, spot check procedures will
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stop and Agency is to then rebalance systems involved, resubmit final report, and again perform spot checks with Contractor and Consultant.

- 3.2.4 When final report has been accepted, Contractor is to submit to Owner, in name of Owner, a certificate equal to AABC National Guaranty Certification or a NEBB Quality Assurance Program Bond, and in addition, Contractor is to submit a written extended warranty from Agency covering one full heating season and one full cooling season, during which time any balancing problems which occur, with exception of minor revision work done during scheduled site visits, will, at no cost, be investigated by Agency and reported on to Owner, and if it is determined that problems are a result of improper testing, adjusting and balancing, they are to be immediately corrected without additional cost to Owner.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 This Section specifies insulation requirements common to Mechanical Divisions work Sections and it is a supplement to each Section and is to be read accordingly.

1.2 DEFINITIONS

- 1.2.1 "concealed" – means mechanical services and equipment above suspended ceilings, in non-accessible chases, in accessible pipe spaces, and furred-in spaces.
- 1.2.2 "exposed" – means exposed to normal view during normal conditions and operations.
- 1.2.3 "mineral fibre" – includes glass fibre, rock wool, and slag wool.
- 1.2.4 "domestic water" or "potable water" – means piping extended from building Municipal supply main.

1.3 SUBMITTALS

- 1.3.1 At least 4 weeks prior to insulation work commencing, submit a sample of each type of insulation (and insulation accessories and finish), in applied form, for review. Mount samples on a plywood board. Identify each product with manufacturer's name and insulation type, and proposed use of insulation. When sample board has been approved, mechanical insulation work is to conform to approved sample board.
- 1.3.2 Submit a product data sheet for each insulation system product.
- 1.3.3 Submit a fabrication drawing for each custom made cover to indicate material and fabrication details, and a 300 mm (12") square sample of proposed cover material.
- 1.3.4 Submit a colour chart for coloured lagging adhesive for canvas jacketed insulation.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 In accordance with Part 3 of this Section, submit a letter from fire rated duct wrap supplier to certifying duct wrap has been properly installed.

1.5 QUALITY ASSURANCE

- 1.5.1 Mechanical insulation is to be applied by a licensed journeyman insulation mechanic, or by an apprentice under direct, daily, on-site supervision of a journeyman mechanic.
- 1.5.2 Do not apply insulation unless leakage tests have been satisfactorily completed.
- 1.5.3 Ensure surfaces to be insulated are clean and dry.
- 1.5.4 Ensure ambient temperature is minimum 13°C (55°F) for at least 1 day prior to application of insulation, and for duration of insulation work, and relative humidity is and will be at a level such that mildew will not form on insulation materials.
- 1.5.5 Company with sub-contract for mechanical insulation work is to be a member in good standing of Thermal Insulation Association of Canada.
- 1.5.6 Insulation materials must be stored on site in a proper and dry storage area. Any wet insulation material is to be removed from site.

2 PRODUCTS

2.1 FIRE HAZARD RATINGS

- 2.1.1 Unless otherwise specified, insulation system materials inside building must have a fire hazard rating of not more than 25 for flame spread and 50 for smoke developed when

tested in accordance with ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.

2.2 THERMAL PERFORMANCE

- 2.2.1 Unless otherwise specified, thermal performance of insulation is to meet or exceed values given in Tables entitled Minimum Piping Insulation Thickness Heating and Hot Water Systems and Minimum Piping Insulation Thickness Cooling Systems, as stated in ANSI/ASHRAE/IES Standard 90.1 version referenced in Ontario Building Code.

2.3 PIPE INSULATION MATERIALS

- 2.3.1 Horizontal pipe insulation at hangers and supports are to be equal to Belform Insulation Ltd. "Koolphen K-Block" insulated pipe support inserts consisting of minimum 150 mm (6") long, pre-moulded, rigid, sectional phenolic foam insulation (of same thickness as adjoining insulation) with a reinforced foil and kraft paper vapour barrier jacket and a captive galvanized steel saddle.
- 2.3.2 Flexible foam elastomeric is to be closed cell, sleeve type, longitudinally split self-seal, foamed plastic pipe insulation with a water vapour transmission rating of 0.10, in accordance with ASTM E96, Procedure B, and required installation accessories.
- 2.3.2.1 Manufacturers:
- (1) Armacell AP/Armaflex SS;
 - (2) IK Insulation Group K-Flex "LS" Self-Seal Pipe Insulation.
- 2.3.3 Closed cell foamed glass is to be Owens Corning "FOAMGLASS", expanded, sectional, rigid sleeve type insulation with a liquid or vapour permeability rating (as per ASTM C240) of 0.00, and a factory applied "PITWRAP SSII" self-sealing jacket and protective metal cladding.
- 2.3.4 Premoulded mineral wool is to be rigid, sectional, sleeve type, non-combustible, longitudinally split mineral wool, or basalt pipe insulation with a reinforced vapour barrier jacket.
- 2.3.4.1 Manufacturers:
- (1) Roxul "Tecton 1200";
 - (2) IIG (Johns Manville Inc.) MinWool-1200;
 - (3) Paroc 1200.
- 2.3.5 Fire rated pre-moulded mineral wool is to be non-combustible, fire-rated, rigid, sectional, longitudinally split mineral wool or basalt pipe insulation with a reinforced vapour barrier jacket and compatible with ULC-S115 and ULC-S101 firestopping.
- 2.3.5.1 Manufacturers:
- (1) Roxul "Tecton 1200";
 - (2) IIG (Johns Manville Inc.) MinWool-1200;
 - (3) Paroc 1200.
- 2.3.6 Pre-moulded mineral fibre is to be rigid, sectional, sleeve type insulation to ASTM C547, with a factory applied vapour barrier jacket.
- 2.3.6.1 Manufacturers:
- (1) Johns Manville Inc. "Micro-Lok AP-T Plus";
 - (2) Knauf Fiber Glass "Pipe Insulation" with "ASJ-SSL" jacket;
 - (3) Manson Insulation Inc. "ALLEY K APT";
 - (4) Owens Corning "Fiberglas" Pipe Insulation.
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- 2.3.7 Blanket mineral fibre is to be blanket type roll insulation to CGSB 51-GP-11M, 24 kg/m³ (1-½ lb/ft³) density, with a factory applied vapour barrier facing.

2.3.7.1 Manufacturers:

- (1) Johns Manville Inc. Microlite FSK Duct Wrap Type 150;
- (2) Knauf Fiber Glass Blanket Insulation FSK Duct Wrap Type III;
- (3) Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap Type III;
- (4) Certainteed Corporation Softtouch FSK Duct Wrap Type 150.

- 2.3.8 Pre-moulded weatherproof jacketed mineral fibre is to be Knauf Insulation "Redi-Klad 1000" sectional, sleeve type pipe insulation with a self-sealing weather-proof jacket and a 100 mm (4") butt joint sealing strip with each section.

2.4 BARRIER-FREE LAVATORY PIPING INSULATION KITS

- 2.4.1 Removable, flexible, reusable, white moulded plastic insulation kits for barrier-free lavatory drain piping and potable water supplies exposed under lavatory.

2.4.2 Manufacturers:

- 2.4.2.1 Truebo "Lav-Guard 2" E-Z Series;
- 2.4.2.2 Zeston "SNAP-TRAP";
- 2.4.2.3 McGuire Manufacturing Co. Inc. "ProWrap".

2.5 EQUIPMENT INSULATION MATERIALS

- 2.5.1 Blanket mineral fibre is to be blanket type roll form insulation to ASTM C553, 24 kg/m³ (1-½ lb/ft³) density, with a factory applied vapour barrier facing.

2.5.1.1 Manufacturers:

- (1) Johns Manville Inc. Microlite FSK Duct Wrap Type 150;
- (2) Knauf Fiber Glass Blanket Insulation FSK Duct Wrap Type III;
- (3) Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap Type III;
- (4) Certainteed Corporation Softtouch FSK Duct Wrap Type 150.

- 2.5.2 Semi-rigid mineral fibre board is to be roll form, moulded insulation to ASTM C1393, with a factory applied vapour barrier facing consisting of laminated aluminum foil and kraft paper.

2.5.2.1 Manufacturers:

- (1) Knauf Fiber Glass Pipe and Tank Insulation;
- (2) Manson Insulation Inc. "AK FLEX";
- (3) Johns Manville Inc. Pipe and Tank Insulation "Micro-Flex";
- (4) Multi-Glass Insulation Ltd. "MULTI-FLEX MF";
- (5) Owens Corning Pipe and Tank Insulation;
- (6) Glass-Cell Fabricators Ltd. "R-Flex".

- 2.5.3 Semi-rigid mineral wool blanket is to be equal to Roxul "Enerwrap MA 960" flexible, black fibrous scrim faced mineral wool blanket insulation to ASTM C553.

- 2.5.4 Closed cell foamed glass is to be Owens Corning "FOAMGLAS" expanded, rigid board and block type insulation with a liquid or vapour permeability rating (as per ASTM C240) of 0.00.
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2.6 REMOVABLE/REUSABLE INSULATION COVERS

- 2.6.1 Valve, etc. covers are to be NO SWEAT reusable insulation wraps with vapour barrier jacket and self-sealing ends and longitudinal seam, with a length to suit the application and an insulation thickness equal to adjoining insulation.
- 2.6.2 Custom manufactured equipment covers conforming to shape of item to be insulated, designed to be easily removable and replaceable to suit use and maintenance procedures of particular item, and to provide adequate personnel protection. Covers are to be complete with minimum 95 kg/m³ (6 lb/ft³) density ceramic fibre insulation sewn between minimum 542.5 g/m² (1.8 oz/ft²) weight silicone impregnated fibreglass fabric in a quilted pattern using double stitches made with Kelvar or Teflon coated fibreglass thread. Overlap flaps are to be secured using laces, snaps, or Velcro double stitched in place.
- 2.6.3 Manufacturers:
 - 2.6.3.1 Crossby Dewar Inc.;
 - 2.6.3.2 Insufab Systems Inc.;
 - 2.6.3.3 ADL Insulflex Inc.;
 - 2.6.3.4 Firwin Corp.;
 - 2.6.3.5 GlassCell Isofab Inc.

2.7 DUCTWORK SYSTEM INSULATION MATERIALS

- 2.7.1 Rigid mineral fibre board is to be pre-formed board type insulation to ASTM C612, 48 kg/m³ (3 lb/ft³) density, with a factory applied reinforced aluminum foil and kraft paper facing.
 - 2.7.1.1 Manufacturers:
 - (1) Knauf Fiber Glass Insulation Board with FSK facing;
 - (2) Manson Insulation Inc. "AK BOARD FSK";
 - (3) Johns Manville Inc. Type 814 "Spin-Glas";
 - (4) Owens Corning 703.
 - 2.7.2 Semi-rigid mineral fibre board is to be roll form insulation to ASTM C1393, consisting of cut strips of rigid mineral board insulation glued to an aluminium foil and kraft paper facing.
 - 2.7.2.1 Manufacturers:
 - (1) Multi-Glass Insulation Ltd. "Multi-Flex MKF";
 - (2) Glass-Cell Fabricators Ltd. "R-FLEX";
 - (3) Owens Corning Pipe and Tank Insulation;
 - (4) Johns Manville Inc. Pipe and Tank Insulation.
 - 2.7.3 Blanket mineral fibre is to be blanket type roll form insulation to ASTM C553, 24 kg/m³ (1-½ lb/ft³) density, 40 mm (1-½") thick, with a factory applied vapour barrier facing.
 - 2.7.3.1 Manufacturers:
 - (1) Johns Manville Inc. Microlite FSK Duct Wrap Type 150;
 - (2) Knauf Fiber Glass Blanket Insulation FSK Duct Wrap Type III;
 - (3) Manson Insulation Inc. ALLEY WRAP FSK Duct Wrap Type III;
 - (4) Certainteed Corporation Softtouch FSK Duct Wrap Type 150.
 - 2.7.4 Pre-moulded calcium silicate is to be rigid block and sheet insulation.
 - 2.7.4.1 Manufacturers:
 - (1) Johns Manville Inc. "Thermo-12 Gold";
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(2) Industrial Insulation Group "Thermo-12 Gold".

2.7.5 Flexible foam elastomeric sheet is to be sheet form, CFC free, closed cell, self-adhering elastomeric nitrile rubber insulation with a water vapour permeability rating of 0.08, in accordance with ASTM E96 Procedure A.

2.7.5.1 Manufacturers:

(1) Armacell "AP/Armaflex SA";

(2) IK Insulation Group "K-Flex Duct Wrap", S2S.

2.7.6 Extruded polystyrene tapered insulation – equal to Soprema Sopra-ISO Tapered, closed cell polyisocyanurate foam core with organic facers reinforced with glass fibres, 172 kPa compressive strength as per ASTM D1621, 32 kg/m³ density, 50 mm minimum thickness, 2% slope. Thickness shall increase if width of duct work is larger than 1200 mm to maintain 2% slope.

2.8 FIRE RATED DUCT WRAP

2.8.1 Flexible, non-combustible, blanket type mineral fibre duct wrap completely encapsulated in reinforced foil, suitable for installation with zero clearance to combustibles (for grease ducts), and ULC tested and listed (ULC Designs FRD-17 & 23 for ventilation ducts, ULC Design FRD-19 for kitchen exhaust/grease duct) to facilitate a 2 hour fire resistance rating (76 mm (3") thick) to kitchen grease exhaust duct in accordance with requirements of NFPA-96, and/or a 1 hour or 2 hour fire resistance rating (38 mm (1-½") thick) to ventilation or pressurization ductwork in accordance with requirements of ISO 6944.

2.8.2 Manufacturers:

2.8.2.1 3M Fire Barrier Duct Wrap 615;

2.8.2.2 CL4 Inc. "CL4Fire";

2.8.2.3 Unifrax Corp. "FyreWrap Elite 1.5";

2.8.2.4 Morgan Thermal Ceramics "FireMaster FastWrap XL".

2.9 INSULATING COATINGS

2.9.1 Equal to Robson Thermal Manufacturing Ltd. insulating coatings as follows:

2.9.1.1 anti-condensation coating, "No Sweat-FX";

2.9.1.2 thermal insulating coating, "ThermaLite".

2.10 INSULATION FASTENINGS

2.10.1 Wire – minimum 15 gauge galvanized annealed wire.

2.10.2 Wire with Mesh – minimum 15 gauge galvanized annealed wire factory woven into 25 mm (1") hexagonal mesh.

2.10.3 Aluminium Banding – equal to ITW Insulation Systems Canada "FABSTRAPS" minimum 12 mm (½") wide, 0.6 mm (1/16") thick aluminium strapping.

2.10.4 Stainless Steel Banding – equal to ITW Insulation Systems Canada "FABSTAPS" 0.6 mm (1/16") thick, minimum 12 mm (½") wide type 304 stainless steel strapping.

2.10.5 Duct Insulation Fasteners – weld-on 2 mm (3/32") diameter zinc coated steel spindles of suitable length, complete with minimum 40 mm (1-½") square plastic or zinc plated steel self-locking washers.

2.10.6 Tape Sealant – equal to MACtac Canada Ltd. self-adhesive insulation tapes, types PAF, FSK, ASJ, or SWV as required to match surface being sealed.

2.10.7 Mineral Fibre Insulation Adhesive – clear, pressure sensitive, brush consistency adhesive, suitable for a temperature range of -20°C to 82°C (-4°F to 180°F), compatible with type of material to be secured, and WHMIS classified as non-hazardous.

2.10.8 Flexible Elastomeric Insulation Adhesive – Armacell "Armaflex" #520 air-drying contact adhesive.

- 2.10.9 Closed Cell Foamed Glass Insulation Adhesive – Pittsburgh Corning PC88 multi-purpose 2-component adhesive.
- 2.10.10 Lagging Adhesive – white, brush consistency, ULC listed and labelled, 25/50 fire/smoke rated lagging adhesive for canvas jacket fabric, suitable for colour tinting, complete with fungicide and washable when dry.
- 2.10.11 Screws – No. 10 stainless steel sheet metal screws.

2.11 INSULATION JACKETS AND FINISHES

- 2.11.1 Canvas Jacket Material – ULC listed and labelled, 25/50 fire/smoke rated, roll form, minimum 170 g (6 oz.).
- 2.11.2 Roll Form Sheet and Fitting Covers – minimum 15 mm (1/2") thick white PVC, 25/50 fire/smoke rated tested in accordance with ULC S102, complete with installation and sealing accessories.
 - 2.11.2.1 Manufacturers:
 - (1) Proto Corp. "LoSMOKE";
 - (2) The Sure-Fit System "SMOKE-LESS 25/50";
 - (3) Johns Manville Inc. "Zeston" 300.
- 2.11.3 Rigid Aluminium Jacket – equal to ITW Insulation Systems Canada "Lock-on" 0.406 mm (0.016") thick embossed aluminum jacket material to ASTM B209, factory cut to size and complete with polysurlyn moisture barrier and continuous modified Pittsburgh Z-Lock, butt straps with "Fabstraps" to weatherproof the end to end joints, and 2-piece epoxy coated pressed aluminum fittings with weather locking edges.
- 2.11.4 Stainless Steel Jacket – equal to ITW Insulation Systems Canada "Lock-on" 0.254 mm (0.010") thick type 304 embossed stainless steel jacket material to ASTM A240, factory cut to size and complete with moisture barrier and continuous modified Pittsburgh Z-Lock, butt straps with "Fabstraps" to cover end to end joints, and 2-piece pressed stainless steel fittings with weather locking edges.
- 2.11.5 Adhesive backed flexible aluminium is to be MFM Building Products Corp. "Flex-Clad 400" roll form sheet material with an aggressive rubberized asphalt adhesive backing, high density polyethylene reinforcement, and an embossed aluminum facing.
- 2.11.6 Heat resistant, trowel consistency thermal insulating and finishing cement to CAN/CGSB 51.12, and suitable for the application.
- 2.11.7 Foamed glass insulation protective coating is to be Pittsburgh Corning "PITTCOTE 300e" flexible acrylic latex weather barrier coating, white unless otherwise specified.
- 2.11.8 UV and moisture resistant flexible foam insulation with protective jacket equal to Armacell "ArmaFlex Shield".
- 2.11.9 Self adhesive multilayer jacketing - equal to 3M Ventureclad 1577CW. Multi-ply laminate flexible jacketing, acrylic adhesive, zero permeability vapor barrier, 480 N/mm tensile strength, 22N/25 mm peel adhesion strength, 15.2 kPa shear adhesion after 72 hours, 147 N puncture resistance, 0.2 mm thickness.

3 EXECUTION

3.1 GENERAL INSULATION APPLICATION REQUIREMENTS

- 3.1.1 Unless otherwise specified, do not insulate following:
 - 3.1.1.1 factory insulated equipment and piping;
 - 3.1.1.2 heating piping within radiation unit enclosures, including blank filler sections of enclosures;

- 3.1.1.3 heating piping in soffits and/or overhang spaces and connected to bare element radiation in spaces;
- 3.1.1.4 branch potable water piping located under counters to serve counter mounted plumbing fixtures and fittings, except barrier-free lavatories;
- 3.1.1.5 exposed chrome plated potable water angle supplies from concealed piping to plumbing fixtures and fittings, except barrier-free lavatories;
- 3.1.1.6 heated liquid system pump casings, valves, strainers and similar accessories;
- 3.1.1.7 heating system expansion tanks;
- 3.1.1.8 fire protection pump casings;
- 3.1.1.9 manufactured expansion joints and flexible connections;
- 3.1.1.10 acoustically lined ductwork and/or equipment;
- 3.1.1.11 factory insulated flexible branch ductwork;
- 3.1.1.12 fire protection system water storage tanks;
- 3.1.1.13 piping unions, except for unions in "cold" category piping.
- 3.1.2 Install insulation directly over pipes and ducts, not over hangers and supports.
- 3.1.3 Install piping insulation and jacket continuous through pipe openings and sleeves.
- 3.1.4 Install duct insulation continuous through walls, partitions, and similar surfaces except at fire dampers.
- 3.1.5 When insulating "cold" piping and equipment, extend insulation up valve bodies and other such projections as far as possible, and protect insulation jacketing from the action of condensation at its junction with metal.
- 3.1.6 Insulate, vapour seal, and finish seismic restraints, braces, anchors, hanger rods, and similar hardware directly connected to "cold" piping and/or equipment, for a distance of 300 mm (12") clear of adjacent pipe or equipment finish, to match piping and/or equipment insulation.
- 3.1.7 When insulating vertical piping risers 75 mm (3") diameter and larger, use insulation support rings welded directly above lowest pipe fitting, and thereafter at 4.5 m (14.7') centres and at each valve and flange. Insulate as per Thermal Insulation Association of Canada National Insulation Standards, Figure No. 9.
- 3.1.8 Where piping and/or equipment is traced with electric heating cable, ensure cable has been tested and accepted prior to application of insulation, and ensure cable is not damaged or displaced during the application of insulation.
- 3.1.9 Where existing insulation work is damaged as a result of mechanical work, repair damaged insulation work to Project work standards.
- 3.1.10 Where mineral fibre rigid sleeve type insulation is terminated at valves, equipment, unions, etc., neatly cover exposed end of insulation with a purpose made PVC cover on "cold" piping, and with canvas jacket material on "hot" piping.
- 3.1.11 Carefully and neatly gouge out insulation for proper fit where there is interference between weld bead, mechanical joints, etc., and insulation. Bevel away from studs and nuts to permit their removal without damage to insulation, and closely and neatly trim around extending parts of pipe saddles.
- 3.1.12 Where thermometers, gauges, and similar instruments occur in insulated piping, and where access to heat transfer piping balancing valve ports and similar items are required, create a neat, properly sized hole in insulation and provide a suitable grommet in the opening.

3.2 INSULATION FOR HORIZONTAL PIPE AT HANGERS AND SUPPORTS

- 3.2.1 At each hanger and support location for piping 50 mm (2") diameter and larger and scheduled to be insulated, except where roller hangers and/or supports are required, and unless otherwise specified, supply a factory fabricated section of phenolic foam pipe

insulation with integral vapour barrier jacket and captive galvanized steel shield. Supply insulation sections to piping installers for installation as pipe is erected.

- 3.2.2 For 100 mm (4") diameter and larger heating system piping where roller type hangers and supports are provided, a steel saddle will be tack welded to pipe at each roller hanger or support location. Pack saddle voids with loose mineral wool insulation.

3.3 PIPE INSULATION REQUIREMENTS – MINERAL FIBRE

- 3.3.1 Insulate following pipe inside building and above ground with mineral fibre insulation of thickness indicated:
- 3.3.1.1 domestic cold water piping, less than 100 mm (4") dia. – 25 mm (1") thick;
 - 3.3.1.2 domestic cold water piping, greater than or equal to 100 mm (4") dia. – 40 mm (1-½") thick;
 - 3.3.1.3 domestic hot water piping, less than 40 mm (1-½") dia. – 25 mm (1") thick;
 - 3.3.1.4 domestic hot water piping, greater than or equal to 40 mm (1½") dia. – 40 mm (1-½") thick;
 - 3.3.1.5 tempered domestic water piping, supply and return, less than 40 mm (1-½") dia. – 25 mm (1") thick;
 - 3.3.1.6 tempered domestic water piping, supply and return, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - 3.3.1.7 storm drainage piping from roof drains to the point where main vertical risers extend straight down, without offsets, and connect to horizontal underground mains – 25 mm (1") thick;
 - 3.3.1.8 condensate drainage piping from fan coil unit or any other air conditioning system/unit drain pans to main vertical drain risers or to indirect drainage point – 25 mm (1") thick;
 - 3.3.1.9 drainage piping from refrigerated drinking fountains to nearest 75 mm (3") dia. or larger drain pipe – 25 mm (1") thick;
 - 3.3.1.10 chilled water piping, supply and return, less than 100 mm (4") dia. – 25 mm (1") thick;
 - 3.3.1.11 chilled water piping, supply and return, greater than or equal to 100 mm (4") dia. – 40 mm (1-½") thick;
 - 3.3.1.12 chilled glycol solution piping, supply and return, less than 100 mm (4") dia. – 25 mm (1") thick;
 - 3.3.1.13 chilled glycol solution piping, supply and return, greater than or equal to 100 mm (4") dia. – 40 mm (1-½") thick;
 - 3.3.1.14 hot water heating piping, supply and return, less than 40 mm (1-½") dia. – 40 mm (1-½") thick;
 - 3.3.1.15 hot water heating piping, supply and return, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - 3.3.1.16 glycol solution heating or heat reclaim piping, supply and return, less than 40 mm (1-½") dia. – 40 mm (1-½") thick;
 - 3.3.1.17 glycol solution heating or heat reclaim piping, supply and return, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - 3.3.1.18 low pressure (to 140 kPa (20 psi)) steam piping, less than 100 mm (4") dia. – 65 mm (2-½") thick;
 - 3.3.1.19 low pressure (to 140 kPa (20 psi)) steam piping, greater than or equal to 100 mm (4") dia. – 80 mm (3") thick;
 - 3.3.1.20 medium pressure (140 kPa to 415 kPa (20 psi to 60 psi)) steam piping, less than 40 mm (1-½") dia. – 100 mm (4") thick;
 - 3.3.1.21 medium pressure (140 kPa to 415 kPa (20 psi to 60 psi)) steam piping, greater than or equal to 40 mm (1-½") dia. – 112 mm (4-½") thick;
 - 3.3.1.22 low pressure condensate piping, less than 40 mm (1-½") dia. – 40 mm (1-½") thick;
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- 3.3.1.23 low pressure condensate piping, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - 3.3.1.24 medium pressure condensate piping, less than 40 mm (1-½") dia. – 40 mm (1-½") thick;
 - 3.3.1.25 medium pressure condensate piping, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;
 - 3.3.1.26 boiler feedwater piping complete – 25 mm (1") thick;
 - 3.3.1.27 boiler blowdown piping complete – 40 mm (1-½") thick;
 - 3.3.1.28 chilled domestic cold water piping from remote water cooler(s) to drinking fountain(s) – 40 mm (1-½") thick;
 - 3.3.1.29 piping indicated to be traced with electric heating cable – minimum 50 mm (2") thick;
 - 3.3.1.30 drum drip(s) in dry zone standpipe and/or sprinkler system piping – 50 mm (2") thick;
 - 3.3.1.31 refrigerant suction piping (between compressor and evaporator coil) inside building – 25 mm (1") thick;
 - 3.3.1.32 refrigerant hot gas piping (between compressor and condenser) inside building – 25 mm (1") thick;
 - 3.3.1.33 refrigerant hot gas by-pass piping (between compressor discharge and evaporator coil) inside building – 25 mm (1") thick;
 - 3.3.1.34 air compressor set fresh air intake piping – 25 mm (1") thick;
 - 3.3.1.35 heat pump equipment earthloop piping – 25 mm (1") thick.
 - 3.3.2 Secure overlap flap of the sectional insulation jacket tightly in place. Cover section to section butt joints with tape sealant.
 - 3.3.3 Insulate fittings with sectional pipe insulation mitred to fit tightly, and cover butt joints with tape sealant, or, alternatively, wrap fittings with blanket mineral fibre insulation to a thickness and insulating value equal to the sectional insulation, secure in place with adhesive and/or wire, and cover with PVC fitting covers.
 - 3.3.4 Unless otherwise specified, insulate unions, valves, strainers, and similar piping system accessories in "cold" piping with cut and tightly fitted segments of sectional pipe insulation with joints covered with tape sealant, or, alternatively, wrap piping union, valve, strainer, etc., with blanket mineral fibre and cover with PVC covers as for paragraph above.
 - 3.3.5 Terminate sectional insulation approximately 50 mm (2") from flange or coupling on each side of flange or coupling. Cover flange or coupling with a minimum 50 mm (2") thickness of blanket mineral fibre insulation wide enough to butt tightly to ends of adjacent sectional insulation. Secure blanket insulation in place and cover with a purpose made PVC coupling cover.
 - 3.3.6 Drum drips in dry zone sprinkler and/or standpipe system piping will be traced with electric heating cable as part of electrical work, and are generally not shown on drawing(s). Confirm number and size of drum drips required with trade providing piping and include for insulation to suit. Wherever possible drum drips will be located in heated areas.
 - 3.3.7 Take special care at concealed water rough-in piping at plumbing fixtures to ensure piping is properly insulated. If necessary due to space limitations, use 12 mm (½") thick sectional pipe insulation in lieu of 25 mm (1") thick insulation.
 - 3.3.8 Insulate seismic restraint hardware such as hanger rods, braces, anchors, etc., directly connected to "cold" category piping and equipment for a distance of 300 mm (12") from piping or equipment with insulation and finish to match pipe or equipment insulation. Coat seismic restraint hardware for a distance of 300 mm (12") from the termination of insulation with Robson Thermal "NO-SWEAT-FX" water based anti-condensation coating.
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3.4 PIPE INSULATION REQUIREMENTS – MINERAL WOOL

- 3.4.1 Insulate following pipe inside building and above ground with high temperature mineral wool insulation of thickness indicated:
 - 3.4.1.1 high pressure (above 415 kPa (60 psi)) steam piping, less than 40 mm (1-½") dia. – 100 mm (4") thick;
 - 3.4.1.2 high pressure (above 415 kPa (60 psi)) steam piping, greater than or equal to 40 mm (1-½") dia. – 115 mm (4-½") thick;
 - 3.4.1.3 high pressure condensate piping – 50 mm (2") thick;
 - 3.4.1.4 engine-generator set exhaust system piping – 75 mm (3") thick.
- 3.4.2 Generally, install insulation on piping as specified above for mineral fibre insulation.
- 3.4.3 Generally, install insulation on fittings as specified above for mineral fibre insulation but cover with canvas, not PVC fitting covers.

3.5 PIPE INSULATION REQUIREMENTS – FLEXIBLE FOAM ELASTOMERIC

- 3.5.1 Install flexible elastomeric pipe insulation in strict accordance with manufacturer's published instructions to suit the application, and using adhesive, joint sealants and finish to produce a water-tight installation. Insulate following pipe with flexible elastomeric pipe insulation of thickness indicated:
 - 3.5.1.1 refrigerant suction and hot gas piping outside building – 25 mm (1") thick.

3.6 PIPE INSULATION REQUIREMENTS – CLOSED CELL FOAMED GLASS

- 3.6.1 Install closed cell foamed glass insulation in strict accordance with manufacturer's published instructions to suit the application, and using adhesive, joint sealants, and jacketing to produce a water-tight installation. Insulate following pipe with closed cell foamed glass of thickness indicated:
 - 3.6.1.1 piping located outside building and indicated to be heat traced – minimum 50 mm (2") thick.

3.7 PIPE INSULATION REQUIREMENTS – FIRE RATED INSULATION

- 3.7.1 Where pipe (inside building and above ground) which is to be insulated as specified above penetrates fire rated construction, provide fire-rated, non-combustible sectional insulation on portion of pipe in fire barrier and for a distance of 50 mm (2") on either side of fire barrier. Insulation thickness is to be as specified, but in any case minimum 25 mm (1").

3.8 INSTALLATION OF WEATHER-PROOF JACKETED INSULATION

- 3.8.1 Install sectional weather-proof jacketed pipe insulation in strict accordance with manufacturer's instructions to produce a water-tight weather-proof installation. Insulate fittings with blanket type glass fibre insulation of a thickness and insulating value equal to the sectional insulation and secured in place with adhesive and wire. Jacket fittings with manufactured aluminium fitting covers sealed water-tight. Insulate following pipe with weather-proof jacketed insulation:

3.9 INSTALLATION OF BARRIER FREE LAVATORY INSULATION KITS

- 3.9.1 Provide manufactured insulation kits to cover exposed drainage and water piping under barrier free lavatories.

3.10 EQUIPMENT INSULATION REQUIREMENTS – BLANKET TYPE MINERAL FIBRE

- 3.10.1 Insulate following equipment with mineral fibre blanket type insulation of thickness indicated:
 - 3.10.1.1 chilled water and/or domestic cold water pump casings – 40 mm (1-½") thick;

- 3.10.1.2 roof drain sumps where inside the building – 25 mm (1") thick;
- 3.10.1.3 water meter(s) – 40 mm (1-½") thick;
- 3.10.1.4 top of radiant ceiling panels – per manufacturer's recommendation or minimum 50 mm (2") thick, whichever is greater.
- 3.10.2 Unless otherwise noted, wrap equipment to a thickness and insulating value equal to an equivalent thickness of rigid sectional pipe insulation. Laminate insulation in place with a full coverage of adhesive and secure with wire. Apply a jacket of insulation vapour barrier material secured in place with adhesive or sealant tape.
- 3.10.3 Cover roof drain sumps with purpose made PVC fitting covers.
- 3.10.4 Lay fibreglass blanket on radiant ceiling panels after testing is complete.

3.11 EQUIPMENT INSULATION REQUIREMENTS – SEMI-RIGID MINERAL FIBRE

- 3.11.1 Insulate following equipment with semi-rigid mineral fibre board insulation of thickness indicated:
 - 3.11.1.1 refrigeration machine water chiller(s) and suction elbow(s) – 50 mm (2") thick;
 - 3.11.1.2 uninsulated domestic hot water storage tank(s) – 40 mm (1-½") thick;
 - 3.11.1.3 shell and tube type heat exchangers – 40 mm (1-½") thick;
 - 3.11.1.4 condensate receiver(s) – 40 mm (1-½") thick;
 - 3.11.1.5 flash tanks – 40 mm (1-½") thick;
 - 3.11.1.6 hot well tank – 40 mm (1-½") thick;
 - 3.11.1.7 deaerating feedwater heater – 40 mm (1-½") thick;
 - 3.11.1.8 blow-down tank – 40 mm (1-½") thick;
 - 3.11.1.9 chilled water or chilled glycol solution storage tank – 50 mm (2") thick;
 - 3.11.1.10 heating main air separator – 40 mm (1-½") thick;
 - 3.11.1.11 chilled water expansion tank – 40 mm (1-½") thick.
- 3.11.2 Install insulation as required to fit shape and contour of equipment. Secure insulation in place with adhesive, and with aluminum straps on 450 mm (18") centres. Apply a 6 mm (¼") thick skim coat of insulating cement, then, when insulating cement has dried, apply a 6 mm (¼") thick coat of cement trowelled smooth.
- 3.11.3 For "cold" equipment, prime insulation with suitable sealer and apply a jacket of glass thread reinforced foil and kraft paper vapour barrier jacket material laminated in place with a full coverage of adhesive.
- 3.11.4 Provide removable and replaceable insulated metal covers for equipment with removable heads to permit heads to be removed and replaced without damaging adjacent insulation work.

3.12 EQUIPMENT INSULATION REQUIREMENTS – SEMI-RIGID MINERAL WOOL

- 3.12.1 Insulate following equipment with calcium silicate equipment insulation of thickness indicated:
 - 3.12.1.1 engine-generator set exhaust system silencer(s) – 75 mm (3") thick;
 - 3.12.1.2 uninsulated boiler breeching where inside the building – 75 mm (3") thick.
- 3.12.2 Cut or mitre insulation (or use factory scored type insulation) to fit shape and contour of equipment and secure insulation in place with aluminum straps on 450 mm (18") centres. Point joints, mitres, scores and gaps with insulating cement. Apply a 12 mm (½") thick coat of insulating cement and trowel smooth.

3.13 EQUIPMENT INSULATION REQUIREMENTS – REMOVABLE/REUSABLE TYPE

- 3.13.1 Provide custom designed and manufactured removable and reusable insulation covers for following:
 - 3.13.1.1 plate type heat exchanger(s);
 - 3.13.1.2 150 mm (6") dia. and larger piping strainers, backflow preventers, etc.;
 - 3.13.1.3 diesel engine exhaust manifolds;

- 3.13.1.4 150 mm (6") dia. and larger steam traps and similar equipment.
- 3.13.2 Provide "wrap type" removable and reusable insulation covers for "cold" circuit balancing valves, backflow preventers, and similar items, and for steam traps and similar items requiring service in piping less than 150 mm (6") dia.

3.14 DUCTWORK INSULATION REQUIREMENTS – MINERAL FIBRE

- 3.14.1 Insulate following ductwork systems inside building and above ground with mineral fibre insulation of thickness indicated:
 - 3.14.1.1 Outdoor air and combustion air intake ductwork, casings and plenums from fresh air intakes to and including mixing plenums or sections, or, if mixing plenums or sections are not provided, to first heating coil, or if both mixing plenums or sections and heating coil sections are not provided, and fresh air is not tempered, then the fresh air ductwork system complete – minimum 40 mm (1-½") thick as required;
 - 3.14.1.2 mixed supply air or preheated supply air casings, plenums and sections to and including the fan section where not factory insulated – minimum 25 mm (1") thick rigid board or minimum 40 mm (1-½") thick flexible blanket as required;
 - 3.14.1.3 supply air ductwork outward from fans, except for supply ductwork exposed in area it serves – minimum 25 mm (1") thick rigid board or minimum 40 mm (1-½") thick flexible blanket as required;
 - 3.14.1.4 exhaust discharge ductwork for a distance of 3 m (10') downstream (back) from exhaust openings to atmosphere, including any exhaust plenums within the 3 m (10') distance – minimum 25 mm (1") thick rigid board or minimum 40 mm (1-½") thick flexible blanket as required;
 - 3.14.1.5 any other ductwork, casings, plenums or sections specified or detailed on drawings to be insulated – thickness as specified.
 - 3.14.2 Provide rigid board type insulation for casings, plenums, and exposed rectangular ductwork. Provide blanket type insulation for round ductwork and concealed rectangular ductwork.
 - 3.14.3 Liberally apply adhesive to surfaces of exposed rectangular ducts and/or casings. Accurately and neatly press insulation into adhesive with tightly fitted butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom and side surfaces. Secure and seal joints with 75 mm (3") wide tape sealant. Additional installation requirements as follows:
 - 3.14.3.1 at trapeze hanger locations, install insulation between duct and hanger;
 - 3.14.3.2 provide drywall type metal corner beads on edges of ductwork, casings and plenums in equipment rooms, service corridors, and any other area where insulation is subject to accidental damage, and secure in place with tape sealant.
 - 3.14.4 Liberally apply adhesive to surfaces of concealed rectangular or oval ductwork, and wrap insulation around duct with a top butt joint and tight section to section butt joints. Provide pin and washer insulation fasteners at 300 mm (12") centres on bottom surfaces. Secure and seal joints with 75 mm (3") tape sealant. At each trapeze type duct hanger, provide a 100 mm (4") wide full length piece of rigid mineral fibre board insulation between duct and hanger.
 - 3.14.5 Accurately cut sections of insulation to fit tightly and completely around exposed and concealed round or oval ductwork. Liberally apply adhesive to surfaces of duct, and wrap insulation around duct with a top butt joint and tight section to section butt joints. Seal joints with tape sealant. At duct hanger locations install insulation between duct and hanger. At each hanger location for concealed ductwork where flexible blanket insulation is used, provide a 100 mm (4") wide full circumference strip of semi-rigid board type duct insulation between duct and hanger.
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- 3.14.6 Insulation application requirements common to all types of rigid ductwork are as follows:
 - 3.14.6.1 at duct connection flanges, insulate flanges with neatly cut strips of rigid insulation material secured with adhesive to side surfaces of flange with a top strip to cover exposed edges of the side strips, then butt the flat surface duct insulation up tight to flange insulation, or, alternatively, increase insulation thickness to depth of flange and cover top of flanges with tape sealant;
 - 3.14.6.2 installation of fastener pins and washers is to be concurrent with duct insulation application;
 - 3.14.6.3 cut insulation fastener pins almost flush to washer and cover with neatly cut pieces of tape sealant;
 - 3.14.6.4 accurately and neatly cut and fit insulation at duct accessories such as damper operators (with standoff mounting) and pitot tube access covers;
 - 3.14.6.5 prior to concealment of insulation by either construction finishes or canvas jacket material, patch vapour barrier damage by means of tape sealant.

3.15 DUCTWORK INSULATION REQUIREMENTS – FLEXIBLE ELASTOMERIC

- 3.15.1 Insulate exposed exterior ductwork (except outdoor air intake ductwork) and associated plenums and/or casings outside building with minimum 75 mm (3") thick flexible elastomeric sheet insulation as required, applied in 2 minimum 40 mm (1 ½") thick layers with staggered tightly butted joints.
- 3.15.2 Install with adhesive in strict accordance with manufacturer's instructions to produce a weather-proof installation. Ensure sheet metal work joints are sealed watertight prior to applying insulation.
- 3.15.3 Provide Calcium Silicate insulation between ductwork and duct supports. Tightly butt flexible elastomeric insulation to Calcium Silicate insulation. Cover Calcium Silicate insulation with a continuous sheet of self-adhesive multilayer jacketing which overlaps 75 mm past the Calcium Silicate insulation to the adjacent flexible elastomeric insulation.
- 3.15.4 Provide extruded polystyrene tapered insulation between flexible elastomeric insulation and jacketing to allow for water runoff on all exterior duct work.

3.16 DUCTWORK INSULATION REQUIREMENTS – CALCIUM SILICATE

- 3.16.1 Insulate following kitchen exhaust ductwork with minimum 40 mm (1-½") thick calcium silicate block insulation:
 - 3.16.1.1 kitchen exhaust ductwork from exhaust hood to masonry shaft – 2 hour rating;
 - 3.16.1.2 stairwell pressurization ductwork from fan to stairwell – 1 hour rating;
 - 3.16.1.3 Trauma Room and Operating Room supply and exhaust ductwork complete – 1 hour rating.
- 3.16.2 Secure insulation in place with adhesive and with wire on 450 mm (18") centres. Point gaps and joints with insulating cement. Where ductwork is exposed, cover insulation with wire mesh secured to wire and with edges laced together and apply a coat of finishing cement trowelled smooth. Use drywall type metal corner bead for duct edges where finishing cement is applied.

3.17 DUCT WRAP REQUIREMENTS – FIRE RATED MATERIAL

- 3.17.1 Provide blanket type fire rated duct wrap system material for following ductwork to produce fire rating indicated:
 - 3.17.1.1 kitchen exhaust ductwork from exhaust hood to masonry shaft – 2 hour rating;
 - 3.17.1.2 stairwell pressurization ductwork from fan to stairwell – 1 hour rating;
 - 3.17.1.3 Trauma Room and Operating Room supply and exhaust ductwork complete – 1 hour rating.
 - 3.17.2 Install duct wrap material in accordance with ULC design requirements and supplier's/manufacture's instructions.
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- 3.17.3 Coordinate installation of duct wrap with installation of ductwork.
- 3.17.4 Arrange and pay for duct wrap supplier to examine completed duct wrap system at site. Submit a letter from supplier to certifying duct wrap system has been properly installed.

3.18 APPLICATION OF INSULATING COATINGS

- 3.18.1 Apply, in accordance with manufacturer's instruction, insulating coatings to following bare metal surfaces:
 - 3.18.1.1 paint bare metal surfaces clear of "cold" piping and/or equipment insulation for a distance of from 300 mm (12") to 600 mm (24") clear of pipe or equipment insulation, with "No Sweat-FX" anti-condensation coating;
 - 3.18.1.2 paint bare metal surfaces associated with mechanical systems with an operating temperature 60°C (140°F) with "ThermaLite" insulating coating.
- 3.18.2 Apply coatings with a brush. Remove any splatter or excess coating from adjacent surfaces.

3.19 INSULATION FINISH REQUIREMENTS

- 3.19.1 Unless otherwise shown and/or specified, jacket exposed mineral fibre insulation, and calcium silicate duct insulation work inside building with canvas secured in place with a full covering coat of lagging adhesive. Accurately cut canvas with scissors or a knife. Do not rip or tear canvas to size. Remove lagging adhesive splatter from adjacent uninsulated surfaces.
- 3.19.2 Unless otherwise shown or specified, jacket exposed mineral fibre insulation listed below with canvas jacket secured in place with a full covering coat of coloured lagging adhesive. Accurately cut canvas with scissors or a knife. Do not rip or tear canvas to size. Remove lagging adhesive splatter from adjacent surfaces. Insulated services to receive coloured lagging adhesive are as follows:
 - 3.19.2.1 Chilled Water Piping;
 - 3.19.2.2 Chilled Glycol Piping
 - 3.19.2.3 Condenser Water Piping;
 - 3.19.2.4 Domestic Cold Water Piping;
 - 3.19.2.5 Domestic Hot Water Piping;
 - 3.19.2.6 Domestic Hot Water Recirculation Piping;
 - 3.19.2.7 High Temperature Heating Water Piping;
 - 3.19.2.8 High Temperature Heating Glycol Piping;
 - 3.19.2.9 Heating Water Piping;
 - 3.19.2.10 Condensate Drain Piping;
 - 3.19.2.11 Low Pressure Steam Piping;
 - 3.19.2.12 High Pressure Steam Piping;
 - 3.19.2.13 Indoor Ductwork;
- 3.19.3 Jacket exposed pipe insulation work inside building with white sheet PVC and fitting covers. Install sheet PVC and fitting covers tightly in place with overlapped circumferential and longitudinal joints arranged to shed water. Seal joints to produce a neat water-tight installation. Provide slip-type expansion joints where required by manufacturer's instructions.
- 3.19.4 Install rigid aluminum jacket material tightly in place with overlapped circumferential joints positioned to shed water and covered with butt straps supplied with the jacket. Provide aluminum jacket for following insulation:
 - 3.19.4.1 Chilled Water Piping;
 - 3.19.4.2 Chilled Glycol Piping
 - 3.19.4.3 Condenser Water Piping;
 - 3.19.4.4 High Temperature Heating Water Piping;
 - 3.19.4.5 High Temperature Heating Glycol Piping;

- 3.19.4.6 Heating Water Piping;
 - 3.19.4.7 Condensate Drain Piping;
 - 3.19.4.8 Refrigerant Piping;
 - 3.19.4.9 Outdoor Ductwork;
 - 3.19.5 Install adhesive backed flexible aluminum to cleaned and primed metal surfaces which are between -23°C and 74°C (-10°F and 165°F) in strict accordance with manufacturer's published instructions and details, including shingle type overlap joints to shed water, and use of a hand roller to concentrate pressure on seams. Provide adhesive backed flexible aluminum jacket for following insulation:
 - 3.19.5.1 Chilled Water Piping;
 - 3.19.5.2 Chilled Glycol Piping
 - 3.19.5.3 Condenser Water Piping;
 - 3.19.5.4 High Temperature Heating Water Piping;
 - 3.19.5.5 High Temperature Heating Glycol Piping;
 - 3.19.5.6 Heating Water Piping;
 - 3.19.5.7 Condensate Drain Piping;
 - 3.19.5.8 Refrigerant Piping;
 - 3.19.5.9 Outdoor Ductwork;
 - 3.19.6 Install rigid stainless steel jacket material tightly in place with overlapped circumferential joints positioned to shed water and covered with butt straps supplied with jacket. Provide stainless steel jacket for following:
 - 3.19.6.1 Chilled Water Piping;
 - 3.19.6.2 Chilled Glycol Piping
 - 3.19.6.3 Condenser Water Piping;
 - 3.19.6.4 High Temperature Heating Water Piping;
 - 3.19.6.5 High Temperature Heating Glycol Piping;
 - 3.19.6.6 Heating Water Piping;
 - 3.19.6.7 Condensate Drain Piping;
 - 3.19.6.8 Refrigerant Piping;
 - 3.19.6.9 Outdoor Ductwork;
 - 3.19.7 Apply 2 heavy coats of "PITTCOTE 300e" coating with 24 hr between coats to foamed glass insulation exposed above grade.
 - 3.19.8 Apply 2 coats (with 24 hr between coats) of specified coating to flexible elastomeric insulation outside building.
 - 3.19.9 Install 3M Ventureclad series 1577CW on insulated ductwork and ensure supports are installed on the outside of the jacketing. Jacketing shall be finished as Flat White. Provide necessary insulation and jacketing materials at the time of duct work installation. Do not penetrate jacketing or install jacketing around duct supports. Provide 24GA G90 38 mm x 38 mm steel angle to protect all corners of rectangular ductwork and install between insulation and jacketing. Steel angle shall be continuous on entire duct work run. Provide additional steel angle between jacketing and duct support. Ensure jacketing is continuous with minimum 75 mm (or as required by manufacturer) overlapping on all joints. Provide jacketing on the following duct work:
 - 3.19.9.1 Exposed exterior duct work including outdoor air intake duct work, plenums and casings installed outside;
 - 3.19.9.2 Exposed interior insulated duct work;
 - 3.19.9.3 Interior outdoor air intake duct work, plenums, and casings;
 - 3.19.9.4 Single wall plenum casings (intake or exhaust) field insulated;
 - 3.19.9.5 Wherever indicated on drawings;
 - 3.19.10 Install 3M Ventureclad series 1577CW on exposed piping and ensure supports are installed on the outside of the jacketing. Do not penetrate or install jacketing around pipe supports. Jacketing shall be finished as Flat White. Provide galvanized insulation shield between insulation and jacketing at support points. Ensure jacketing is continuous with
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minimum 75 mm (or as required by manufacturer) overlapping on all joints. Provide jacketing on the following piping:

- 3.19.10.1 Chilled water;
- 3.19.10.2 Chilled glycol;
- 3.19.10.3 High Temperature Heating Water;
- 3.19.10.4 High Temperature Heating Glycol;
- 3.19.10.5 Heating Water;
- 3.19.10.6 Heating glycol;
- 3.19.10.7 Low pressure steam (<104 kPa);
- 3.19.10.8 Low pressure steam (<104 kPa) condensate;
- 3.19.10.9 Domestic cold water piping;
- 3.19.10.10 Domestic hot water piping;
- 3.19.10.11 Coil condensate drain piping;
- 3.19.10.12 Wherever indicated on drawings.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets to regulatory authority for review and approval prior to submitting to the Consultant. Conform to following requirements:
 - 1.1.1.1 submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings;
 - 1.1.1.2 sprinklers shall be referred to on drawings and product submittals, and be specifically identified by the manufacturer's listed model or series designation. Trade names and other abbreviated listings are not allowed;
 - 1.1.1.3 submit complete CAD layout drawings indicating source of water supply with test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, and zones, all signed and sealed by a qualified professional mechanical engineer registered in jurisdiction of the work as specified below;
 - 1.1.1.4 submit copies of all calculations, including hydraulic calculations, stamped and signed by same engineer who signs layout drawings, and a listing of all design data used in preparing the calculations, system layout and sizing, including occupancy-hazard design requirements;
 - 1.1.1.5 in addition to submitting shop drawings to regulatory authority as specified above, shop drawings must be approved by Owner's insurer prior to being submitted to the Consultant for review.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit a complete sprinkler system test certificate as specified in Part 3 of this Section.

1.3 SPARE PARTS

- 1.3.1 Fill spare sprinkler head cabinet complete with spare heads.

1.4 QUALITY ASSURANCE

- 1.4.1 Fire protection sprinkler system work is to be in accordance with following Codes and Standards:
 - 1.4.1.1 NFPA 13, Standard for the Installation of Sprinkler Systems;
 - 1.4.1.2 CSA B137.2, Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications;
 - 1.4.1.3 CSA B137.3, Rigid Polyvinylchloride (PVC) Pipe for Pressure Applications;
 - 1.4.1.4 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless;
 - 1.4.1.5 ASTM A135, Standard Specification for Electric-Resistance-Welded Steel Pipe;
 - 1.4.1.6 ASTM A234, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;
 - 1.4.1.7 ASTM A536, Standard Specification for Ductile Castings;
 - 1.4.1.8 ASTM A795, Standard Specification for Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use;
 - 1.4.1.9 ANSI/ASME B16.4, Grey Iron Threaded Fittings (Classes 125 and 250);
 - 1.4.1.10 CAN/CSA B64.10, Backflow Preventers and Vacuum Breakers.
- 1.4.2 Fire protection sprinkler work is to be performed by a sprinkler company who is a member in good standing of the Canadian Automatic Sprinkler Association. Site personnel are to be licensed in jurisdiction of the work and under the continuous supervision of a foreman who is an experienced fire protection system installer and a journeyman pipe fitter licensed in jurisdiction of the work.
- 1.4.3 Check and verify dimensions and conditions at site and ensure work can be performed as indicated. Coordinate work with trades at site and accept responsibility for and cost of

making adjustments to piping and/or spacing to avoid interference with other building components.

- 1.4.4 Verify working condition of existing sprinkler system equipment which has direct interface with project work and is to remain. Replace with new equipment where necessary.
- 1.4.5 System components must be ULC listed and labelled.
- 1.4.6 All grooved couplings, and fittings, valves and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
- 1.4.7 All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.5 DESIGN REQUIREMENTS

- 1.5.1 Fire protection sprinkler work is to be designed in accordance with NFPA 13 and Provincial Standards, and, where required, local building and fire department requirements and standards of Owner's Insurer. If water supply flow and pressure test data is not available, conduct Municipal main water flow and pressure tests at nearest fire hydrant to obtain criteria to be used in system design. Include hydrant location and flow and pressure test data with system design calculations.
- 1.5.2 Include for a qualified mechanical professional engineer registered and licensed in the jurisdiction of the work to design the fire protection standpipe work. For requirements regarding Contractor retained engineers, refer to Section 20 05 10 – Mechanical Work General Instructions.
- 1.5.3 Sprinkler /System Occupancy – Hazard Design requirements: In accordance with NFPA 13 occupancy-hazard density requirements, unless otherwise specified.

2 PRODUCTS

2.1 PIPE, FITTINGS, AND JOINTS

- 2.1.1 Pipe, fittings and joints are to be as follows, with exceptions as specified in Part 3 of this Section:
 - 2.1.1.1 PVC
 - (1) Class 200, DR14, rigid, hub and spigot pattern PVC pipe and CSA certified fittings to CAN/CSA B137.2 and B137.3 and complete with gasketed joints.
 - 2.1.1.2 Schedule 40 Steel – Grooved Coupling Joints
 - (1) Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with grooved ends and mechanical fittings and couplings equal to Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 rigid coupling joints. Strap type outlet fittings such as Victaulic "Snap-Let" are not acceptable.
 - 2.1.1.3 Schedule 40 Steel – Screwed and Welded Joints
 - (1) Schedule 40 mild black carbon steel, ASTM A53, Grade B. Screwed piping complete with Class 125 cast iron screwed fittings to ANSI/ASME B16.4. Welded piping complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, long sweep pattern wherever possible.
 - 2.1.1.4 Schedule 10 Steel – Grooved Coupling Joints
 - (1) Schedule 10 mild black carbon steel, ASTM A53, Grade B, complete with grooved ends and fittings and couplings equal to Victaulic "FireLock"

fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 rigid coupling joints.

2.1.1.5 Schedule 10 Steel – Screwed Joints

- (1) Schedule 10 mild black carbon steel, ASTM A53, Grade B, complete with mill or site threaded ends, Class 125 cast iron screwed fittings to ANSI/ASME B16.4, and screwed joints.

2.1.1.6 "Lightwall" Steel – Grooved Coupling Joints

- (1) Commercial quality. "Lightwall" rolled mild carbon steel pipe to ASTM A135, Grade A, complete with a galvanized exterior, grooved ends, and fittings and couplings equal to Victaulic "Fire Lock" grooved fittings and Victaulic Style 009N QuickVic or 005 rigid coupling joints.

2.1.1.7 "Lightwall" Steel – Screwed Joints

- (1) Commercial quality, "Lightwall" rolled mild carbon steel pipe to ASTM A135, Grade A, ULC listed, mill or site threaded, complete with galvanized exterior, Class 125 cast iron screwed fittings to ANSI/ASME B16.4, and screwed joints.

2.1.1.8 Flexible Pipe – Equal to Victaulic "VicFlex"

- (1) The drop system shall consist of a braided type 304 stainless steel flexible tube, zinc plated steel 1" NPT Male threaded nipple for connection to branch-line piping, and a zinc plated steel reducer with a 1/2" or 3/4" NPT female thread for connection to the sprinkler head.
 - (2) Option: Victaulic FireLock IGS Groove Style 108 coupling for connection to branch-line piping, and a zinc plated steel reducer with a female thread for connection to the sprinkler head.
 - (3) The drop shall include a cULus/FM approved Series AH2 braided hose with a bend radius to 2" to allow for proper installation in confined spaces.
 - (4) The hose shall be listed for:
 - (A) (4) bends at 31" length;
 - (B) (5) bends at 36" length;
 - (C) (8) bends at 48" length;
 - (D) (10) bends at 60" length;
 - (E) (12) bends at 72" length.
 - (5) Union joints shall be provided for; ease of installation, prevention of hose torque stresses and on site changing of factory 5.75" straight reducing nipple in reduced spaces under obstructions (optional reducing nipples; 4.83" or 6.57" reducing 90 and 9" or 13" straight reducer x 1/2" or 3/4" outlet) All VicFlex assemblies and related accessories to be installed as per the guidelines and listings in Victaulic submittal 10.85.
 - (6) On T Bar ceiling grid with drop in tile application, the flexible drop shall attach to the ceiling grid using a one-piece open gate Series AB1 bracket. The bracket shall allow installation before the ceiling tile is in place.
 - (7) On T Bar ceiling grid designed for hard lid drywall application; the flexible drop shall attach to the ceiling grid using a one-piece open gate Series AB2 bracket. The bracket shall allow for the vertical adjustment of the reducer/head from below the drywall, post drywall installation.
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- (8) On Hat Furring Channel grid with hard lid drywall application; the flexible drop shall attach to the ceiling grid using a one-piece open gate Series AB4 bracket. The bracket shall allow for the vertical adjustment of the reducer/head from below the drywall, post drywall installation.
 - (9) The braided drop system shall be cULus listed and FM Approved for sprinkler services to 175 psi (1206 kPa).
 - (10) For dry sprinkler heads Victaulic VicFlex dry sprinkler model VS1. The sprinkler shall provide a vertical or horizontal flexible connection with a bend radius to 2", and allow for up to 4 bends. The sprinkler body shall be die cast brass with brass deflector, supplied finished to match application and to architectural direction, and glass bulb with glycerin solution. The product shall consist of a braided type 300 stainless steel flexible hose with a swivel type branch line threaded connection, EPDM gasket seal, with PTFE-coated Beryllium Nickel and stainless-steel spring-seal assembly. The bracket shall be open gate or metal strap to provide for sprinkler placement and alignment. The flexible dry sprinkler and bracket system is UL listed for sprinkler services to 175 psi.
- 2.1.1.9 Copper – Solder Joint
- (1) Type "L" hard drawn seamless copper to ASTM B88, complete with copper solder type fittings to ASME/ANSI B16.18 and soldered joints.
- 2.1.1.10 CPVC Pipe
- (1) Equal to IPEX BlazeMaster solvent weld, orange, SDR 13.5 pipe and Schedule 80 fittings, ULC listed for use in wet pipe automatic sprinkler systems, with a flame spread rating less than 25 and a smoke developed rating less than 50 when tested in accordance with CAN/ULC S102.2, and in accordance with NFPA 13 requirements.
 - (2) Victaulic Standard Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Couplings shall comply with ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
 - (3) Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with NFPA-13. Couplings shall be fully installed at visual pad-to-pad offset contact. Couplings that require exact gapping of bolt pads at specific torque ratings are not permitted.
 - (4) Flexible Type: Use in locations where vibration attenuation and stress relief are required. Victaulic Style 177 (Quick-Vic), Installation ready flexible coupling.

2.2 SERVICE MAIN DOUBLE CHECK VALVE ASSEMBLIES

- 2.2.1 Minimum 1205 kPa (175 psi) rated dual check valve backflow preventer assembly to CAN/CSA B64, complete with tight-closing resilient seated shut-off valves, test cocks and strainer.
 - 2.2.2 Manufacturers:
 - 2.2.2.1 Watts Industries Canada;
 - 2.2.2.2 Zurn/Wilkins;
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2.2.2.3 Apollo Valves (Conbraco Industries).

2.3 SHUT-OFF VALVES

- 2.3.1 Minimum 2070 kPa (300 psi) rated full port brass or bronze body screwed ball valves and lug body or grooved end type butterfly valves.
- 2.3.2 Butterfly valves shall include a pressure responsive seat, and the stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating.
- 2.3.3 Basis of Design: Victaulic Style 705.
- 2.3.4 OS&Y Gate Valves: 1725 kPa (250 psi), grooved ends. Ductile iron body, yoke, and handwheel conforming to ASTM A-536; EPDM coated ASTM A-126-B cast iron disc; ASTM B16 brass rising stem; flanged and epoxy coated ductile iron bonnet; EPDM O-ring stem seals and body gasket. Victaulic Series 771H (Grooved ends) and Series 771F (Grooved x Flanged).
- 2.3.5 Supervised closed applications:
 - 2.3.5.1 Basis of Design: Victaulic Series 707C supervised closed butterfly valve.

2.4 CHECK VALVES

- 2.4.1 Minimum 1725 kPa (250 psi) resilient seat check valves, suitable for vertical or horizontal installations.
- 2.4.2 Basis of Design: Victaulic Series 717.
- 2.4.3 Check valves associated with Fire Department connections and fire pump test connection are to be tapped for site installation of a 20 mm ($\frac{3}{4}$ ") diameter ball drip.

2.5 BALL DRIPS

- 2.5.1 Equal to National Fire Equipment Ltd. Model #A58, 20 mm ($\frac{3}{4}$ ") diameter automatic ball drip.

2.6 SHUT-OFF VALVE SUPERVISORY SWITCHES

- 2.6.1 Tamper-proof supervisory switches, each arranged to activate a fire alarm system trouble alarm condition if the valve is closed or tampered with, each suitable in all respects for the application, and each complete with all required mounting and connection hardware.
- 2.6.2 Actuator housings shall be weatherproof.

2.7 FIRE DEPARTMENT CONNECTIONS

- 2.7.1 Wall mounting polished brass clapper type dual inlet Fire Department connection with 2, 65 mm (2- $\frac{1}{2}$ ") diameter inlets threaded to Fire Department hose requirements and equipped with caps and chains, an outlet sized as shown, and a faceplate.
- 2.7.2 Faceplate is to be polished brass and complete with "AUTO-SPKR" "STANDPIPE" cast-in raised lettering.
- 2.7.3 Exposed metal parts of Fire Department connection are to be chrome plated.
- 2.7.4 At the low point near each fire department connection, install a 90-degree elbow with drain connection to allow for system drainage to prevent freezing.
- 2.7.5 Basis of Design: Victaulic #10-DR.

2.8 SPRINKLER MAIN "LOSS OF PRESSURE" ALARM SENSORS

- 2.8.1 Piping mounted adjustable pressure sensor designed to actuate an alarm upon sensing a loss of pressure in the fire protection main. Switch is to be low voltage or line voltage as required.
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2.9 WATER FLOW ALARM SWITCHES

- 2.9.1 Pipe mounting water flow alarm switch, minimum 1725 kPa (250 psi) rated, designed to actuate two 7 ampere rated (at 125/250 VAC) SPDT snap action switches when water flow exceeds 0.758 L/sec. (10 Imp gpm), complete with a tamper-proof cover with conduit connection opening, a piping saddle and U-bolt, and an automatic reset pneumatic retard device with field adjustable (0 to 70 second) switch actuation delay to reduce false alarms caused by a single or series of transient water flow surges.

2.10 ALARM CHECK VALVES

- 2.10.1 Equal to Victaulic Series 751 FireLock, enamelled cast iron check valve assembly designed for either vertical or horizontal mounting and to actuate alarms when wet type sprinkler system is activated. Assembly is to be minimum 1205 kPa (175 psi) cold water rated with all moving parts constructed of brass, bronze, stainless steel, or EPDM, and is to be complete with:
- 2.10.1.1 pipe, fittings and accessories for site connection of an excess pressure pump;
 - 2.10.1.2 basic trim including piping materials and check valve for an external by-pass, potable water supply and system water supply pressure gauges with gauge test ports and shut-off valves, an angle type main drain valve, and fittings for mounting an alarm test by-pass;
 - 2.10.1.3 alarm test by-pass piping with ball valve to permit alarm testing without operation of alarm valve;
 - 2.10.1.4 alarm trim with pipe and fittings for connection to a water motor alarm, and an adjustable pressure switch for electrical connection to an alarm system upon flow through valve.

2.11 EXCESS PRESSURE PUMPS

- 2.11.1 Close coupled, 1750 RPM, all bronze gear pump sized to maintain sufficient pressure in fire protection main to prevent alarm check valve(s) from initiating flow alarms during fluctuations in pressure of Municipal water supply. Pump is to be complete with:
- 2.11.1.1 stainless steel shaft with maintenance free seal;
 - 2.11.1.2 lifetime lubricated carbon bearings;
 - 2.11.1.3 TEFC motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, and secured to a mounting base;
 - 2.11.1.4 accessory package consisting of flexible suction and discharge connection hoses, a Monel inlet strainer, relief valve factory set at 862 kPa (120 psi), and a steel mounting plate designed to mount pump to alarm check valve flange;
 - 2.11.1.5 power and control panel.
- 2.11.2 Factory pre-wired power and control panel, CSA certified, designed to automatically start and stop pump in response to water pressure variations in the main and consisting of a surface wall mounting NEMA 2 enamelled steel panel with hinged front door equipped with Corbin catch, and following:
- 2.11.2.1 door interlock fused disconnect with HRC fuses;
 - 2.11.2.2 protected type pump starter;
 - 2.11.2.3 door mounted H-O-A rotary selector switch;
 - 2.11.2.4 fused control transformer;
 - 2.11.2.5 115 V adjustable pressure switch to suit the application;
 - 2.11.2.6 set of NO/NC dry contacts for connection of lack of power availability alarm;
 - 2.11.2.7 door mounted "POWER ON" LED.

2.12 WATER MOTOR ALARMS

- 2.12.1 Surface wall mounting water motor driven alarm device consisting of a water motor assembly with 20 mm (¾") diameter inlet and 25 mm (1") or 32 mm (1-¼") diameter drain
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connections, inlet strainer, a red enamelled steel exterior wall mounting strike and gong assembly, a drive shaft sleeve with drive shaft to connect water motor and gong assembly and, at the exterior gong, identification to read "SPRINKLER FIRE ALARM - WHEN BELL RINGS CALL FIRE DEPARTMENT OR POLICE".

2.13 DRY PIPE VALVES

- 2.13.1 Equal to a Victaulic Series 768-NXT:
 - 2.13.1.1 Series 746-LPA accelerator quick opening device;
 - 2.13.1.2 Series 757 regulated air maintenance trim assembly;
 - 2.13.1.3 Required air pressure shall be 90 kPa (13 psig);
 - 2.13.1.4 The valve shall be externally resettable;
 - 2.13.1.5 Provide valve complete with internal components that are replaceable without removing valve from installed position;
 - 2.13.1.6 Systems requiring a quick opening device must use a regulated, tank mounted air supply;
 - 2.13.1.7 Series 757 Regulated Air Maintenance Trim Assembly.

2.14 DRY PIPE ZONE AIR COMPRESSOR

- 2.14.1 Equal to a Victaulic 7C7 CSA certified, oil-less, piston type direct driven compressor with a motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, and a mounting bracket.
- 2.14.2 Equal to General Air Products OLT Series, package type, oil-free, piston type, tank mounted air compressor set complete with horizontal, ASME rated and stamped steel tank with support feet, pressure gauge with gauge cock, tank drain, flexible compressor to tank and tank to piping flexible connections supplied loose for field installation, and a motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
- 2.14.3 Compressor set capacity and performance must suit final dry pipe system design and reviewed piping and sprinkler head layout shop drawings. If a larger compressor set than that specified is required, provide larger set at no additional cost, and include any additional costs for a larger size motor starter and associated wiring.

2.15 SPRINKLER HEADS

- 2.15.1 Sprinkler heads, unless otherwise specified, are to be as scheduled in Part 3 of this Section.
 - 2.15.2 Sprinkler body shall be die-cast, with a hex-shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation. Wrenches shall be provided by the sprinkler manufacturer that directly engage the wrench boss.
 - 2.15.3 For locations where corrosive resistant coatings are required, body shall be coated with UL listed and FM approved anti-corrosion VC-250 coating (silver coloring).
 - 2.15.4 Sprinkler heads for healthcare facilities are to be quick response type.
 - 2.15.5 Provide quick response sprinkler heads unless standard response required to suit the hazard class.
 - 2.15.6 Recessed sprinkler heads in finished areas are to be chrome plated unless otherwise specified. Concealed sprinkler head ceiling plates are to match ceiling colour.
 - 2.15.7 Where exposed pendent heads occurs in areas with suspended ceilings, they are to be complete with chrome plated escutcheon plates. Similarly, sidewall heads with concealed piping are to be complete with chrome plated escutcheon plates.
 - 2.15.8 Sprinkler heads which are exposed in areas where they may be subject to damage are to be complete with wire guards, chrome plated where in finished areas.
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- 2.15.9 Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.
- 2.15.10 Sprinkler heads located in areas or over equipment where high ambient temperature is present are to be, unless otherwise specified, 74°C (165°F) heads. All other heads, unless otherwise specified or required, are to be 57°C (135°F) rated.
- 2.15.11 Manufacturers:
 - 2.15.11.1 Victaulic Co.;
 - 2.15.11.2 Tyco Fire Suppression & Building Products;
 - 2.15.11.3 The Viking Corporation;
 - 2.15.11.4 The Reliable Automatic Sprinkler Co.

2.16 SPARE SPRINKLER HEAD CABINETS

- 2.16.1 Surface wall mounting, red enamelled steel, identified cabinet with hinged door, shelves with holes for mounting sprinkler heads, a wrench or wrenches suitable for each type of sprinkler head, and a full complement of spare sprinkler heads.
- 2.16.2 Cabinet is to be sized to accommodate a minimum of 4 spare heads for each type of head used on the project, however, each cabinet is to be full of spare heads.

2.17 INDICATOR POST AND VALVES

- 2.17.1 Cast iron, bronze trim, resilient seat, OS&Y gate valve with non-rising stem in accordance with AWWA 200W, minimum 1380 kPa (200 psi) cold water rated and complete with a square operating nut and ends to suit connecting piping.
- 2.17.2 Adjustable indicator post assembly with a cast iron valve box of a length to suit valve depth and flange bolted to the valve, a cast iron lower barrel bolted to the valve box and of a length to suit valve location, and a cast iron upper housing bolted to the lower barrel and complete with wrench and operating mechanism with steel extension shaft and coupling nut sized to suit, operating handle, and valve "OPEN" and "CLOSED" identification visible through a clear polycarbonate window.

3 EXECUTION

3.1 MONITORING OF SYSTEMS

- 3.1.1 Daily monitor and supervise existing sprinkler system serving renovated areas to ensure that each respective system is left in proper operating condition at end of each working day. Include for but not be limited to performing following:
 - 3.1.1.1 Under presence of Owner's representative, check each morning and evening (start and end of work) of each day, sprinkler system to ensure that it is in proper working condition;
 - 3.1.1.2 If portions of sprinkler system is not in proper working order, provide temporary provisions subject to approval of local fire authority or local governing authority, to ensure that proper sprinkler coverage is provided and/or provide supervisory personnel to monitor areas where sprinkler system is not operational;
 - 3.1.1.3 Document and sign off with Owner's representative signing off also, each respective daily check condition;
 - 3.1.1.4 Ensure that work to sprinkler system does not affect portion of system serving areas outside of renovation areas.

3.2 PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide required sprinkler system piping.
 - 3.2.2 Perform piping work in accordance with requirements of NFPA 13, governing regulations, and "Reviewed" shop drawings.
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- 3.2.3 Piping, unless otherwise specified, is as follows:
 - 3.2.3.1 for underground piping inside or outside building – Class 200, DR14 rigid PVC, braced and secured at bends and tees with concrete blocks in accordance with Municipal standards and details;
 - 3.2.3.2 for piping inside building and above ground except as noted below – Schedule 40 grooved end black steel with Victaulic or equal fittings and coupling joints, or, for piping to and including 50 mm (2") diameter, screwed fittings and joints, or, for piping 65 mm (2-½") diameter and larger, welding fittings and welded joints;
 - 3.2.3.3 for wet system piping inside building and above ground – at your option, CPVC sprinkler pipe and fittings;
 - 3.2.3.4 for piping downstream of "head end" alarm valve(s) and equipment – Schedule 10 or "Lightwall" black steel pipe with Victaulic or equal fittings and coupling joints or screwed fittings and joints;
 - 3.2.3.5 for branch piping to heads in suspended ceilings, etc. – at your option, flexible piping installed in accordance with manufacturer's instructions;
 - 3.2.3.6 for branch piping to heads in MRI suites – copper pipe, fittings, and sprinkler head adapters with stainless steel hangers and support hardware.
 - 3.2.4 Exceptions to piping requirements specified above are as follows:
 - 3.2.4.1 dry pipe zone steel piping, fittings, unions, couplings and flanges are to be galvanized;
 - 3.2.4.2 wet zone steel piping, fittings, unions, couplings and flanges for sprinkler work exposed to weather either inside or outside building (including parking garages), are to be galvanized;
 - 3.2.4.3 PVC piping is not to be used above grade;
 - 3.2.4.4 ferrous pipe hangers, supports, and similar hardware used for galvanized steel piping are to be electro-galvanized.
 - 3.2.5 Pipe sizes, pipe routing, sprinkler head quantities and locations, and layout of work shown on drawings are to assist during the tendering period. Ensure adequate head coverage, head quantities and pipe sizing as specified in Part 1 of this Section. Do not reduce size of sprinkler main or re-route the main unless approved by Consultant.
 - 3.2.6 Pipe, fittings, couplings, flanges and similar components are to be clean after erection is complete. Wire brush clean any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibits rust and carefully coat with suitably coloured primer.
 - 3.2.7 Where sprinklers are not protected by a dry system and may be subject to freezing, provide non-freeze, glycol-water solution filled sprinkler piping. Install piping complete with a CSA certified reduced pressure backflow preventer, valves and glycol solution fill facilities in accordance with requirements of Chapter 3 of NFPA 13. Fill piping with a solution of 50% Union Carbide Canada Ltd. "UCAR THERMO-FLUID 17" or Dow Chemical Co. "Dowtherm SR1" propylene glycol with corrosion inhibitors, and 50% clean water. Prior to filling piping, check the specific gravity of the solution using a hydrometer with proper scale. Specific gravity is to be approximately 1.069 at 15.6°C.
 - 3.2.8 When sprinkler work is complete, test system components and overall system(s) and submit completed test certificate and other documentation in accordance with Chapter 8 of NFPA 13.
 - 3.2.9 Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service. A factory-trained field representative of the mechanical joint manufacturer shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product
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installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products.

3.3 *INSTALLATION OF DOUBLE CHECK VALVE ASSEMBLY*

- 3.3.1 Provide a double check valve assembly in sprinkler main inside the building.
- 3.3.2 Equip assembly with inlet and outlet shut-off valves with supervisory switches as specified below.
- 3.3.3 Support each end of assembly from floor by means of flanged pipe supports with saddles.

3.4 *INSTALLATION OF SHUT-OFF VALVES AND CHECK VALVES*

- 3.4.1 Provide shut-off valves and check valves in piping where shown and wherever else required.
- 3.4.2 Locate valves for easy operation and maintenance.
- 3.4.3 Confirm exact locations prior to roughing-in.

3.5 *INSTALLATION OF SHUT-OFF VALVE SUPERVISORY SWITCHES*

- 3.5.1 Equip each shut-off valve with a supervisory switch.
- 3.5.2 Identify each supervised valve with a 150 mm (6") square, engraved, laminated red-white plastic tag to correspond with supervised valve numbering specified and/or shown as part of the electrical work fire alarm system.

3.6 *INSTALLATION OF FIRE DEPARTMENT CONNECTION*

- 3.6.1 Provide an exterior Fire Department connection. Confirm exact location prior to roughing-in. Confirm finish prior to ordering.
- 3.6.2 Equip connection with a check valve. Equip check valve with a ball drip to drain piping between Fire Department connection and check valve, and extend drainage piping from outlet of ball drip to nearest suitable floor drain.

3.7 *INSTALLATION OF LOSS OF PRESSURE SENSOR*

- 3.7.1 Supply and mount a pressure sensor in the fire protection piping main to activate a "LOSS OF PRESSURE" trouble alarm should Municipal water service pressure fall below the acceptable level.
- 3.7.2 Locate sensor for easy access and maintenance, and set alarm pressure to suit site conditions. Confirm setting on site.
- 3.7.3 Identify pressure sensor and its normal setting with a 150 mm (6") square red-white laminated plastic tag engraved to read "LOSS OF WATER PRESSURE SENSOR - NORMAL SETTING 210 kPa". Confirm wording prior to engraving.

3.8 *INSTALLATION OF FLOW ALARM SWITCHES*

- 3.8.1 Provide water flow alarm switches in accessible locations in zone piping.
- 3.8.2 Adjust to suit site water pressure conditions. Check and test operation.
- 3.8.3 Identify each switch with a 150 mm (6") square red-white laminated engraved plastic tag. Confirm wording prior to engraving.

3.9 *INSTALLATION OF ALARM CHECK VALVES*

- 3.9.1 Provide alarm check valves, complete with trim, for wet zone fire protection sprinkler piping.
-

- 3.9.2 Check and test operation of each valve and adjust as required to suit site water pressure conditions.
- 3.9.3 Identify each valve with a 150 mm (6") square red-white laminated engraved plastic tag. Confirm wording prior to engraving.

3.10 INSTALLATION OF EXCESS PRESSURE PUMP AND CONTROLS

- 3.10.1 Provide an excess pressure pump in wet fire protection sprinkler system piping, arranged to prevent activation of alarm check valve water flow alarms during normal water pressure fluctuations in the main. Locate pump on a steel mounting plate assembly at alarm check valve(s) and install accessories supplied with pump. Provide a pressure gauge in valved tubing across pump suction and discharge connections.
- 3.10.2 Supply a starter and control panel for pump and surface wall mount adjacent to pump. Connect panel pressure switch with copper tubing in accordance with pump manufacturer's instructions. Adjust pressure switch to suit site conditions.
- 3.10.3 Start-up the pump, test operation and adjust as required.

3.11 INSTALLATION OF WATER MOTOR ALARMS

- 3.11.1 Provide a water motor alarm. Secure gong on the exterior wall, impeller and motor assembly on the interior wall, and connect with drive assembly in accordance with manufacturer's instructions. Install inlet strainer supplied loose with assembly.
- 3.11.2 Provide a galvanized steel drain pipe from impeller-motor assembly down the interior wall and terminate piping back out through the wall with a 45° piping elbow and wall plate located 600 mm (24") above finished grade.
- 3.11.3 Confirm exact location of alarm gong prior to roughing-in.
- 3.11.4 When installation is complete, check and test alarm operation and adjust as required.

3.12 INSTALLATION OF DRY PIPE VALVES

- 3.12.1 Provide dry pipe valves for zones.
- 3.12.2 Connect compressed air piping to each valve, as well as all compressed air piping trim.
- 3.12.3 When installation is complete, check and test valve operation and adjust as required.
- 3.12.4 Provide drum drips in dry type fire protection sprinkler zone piping where shown or required. Wherever possible locate drum drips in heated areas. Where drum drips are located in unheated areas ensure trades performing thermal insulation work and electric heating cable pipe tracing work are aware of the number of drum drips required, and the size and location. Identify each drum drip. Locate drum drips in heated areas wherever possible.

3.13 INSTALLATION OF DRY ZONE AIR COMPRESSORS

- 3.13.1 Provide an air compressor with air maintenance device and pressure control for the dry pipe zone and dry pipe valve. Secure compressor to a piping main by means of a mounting bracket supplied with compressor. Adjust to suit site conditions.
 - 3.13.2 Provide an air compressor set with receiver and secure in place on rubber-steel-rubber vibration isolation pads on a concrete housekeeping pad.
 - 3.13.3 Install flexible piping connections supplied loose with set.
 - 3.13.4 Extend valved drain piping from receiver to a floor drain.
 - 3.13.5 Connect receiver and control panel pressure switch with copper tubing.
 - 3.13.6 When installation is complete, check and test air compressor set, including automatic operation, and adjust as required.
-

3.14 **INSTALLATION OF PREACTION SPRINKLER SYSTEMS**

- 3.14.1 Provide a preaction sprinkler system.
- 3.14.2 Install preaction deluge valve cabinet assembly with control panel and air compressor as indicated but confirm exact location prior to roughing-in.
- 3.14.3 Provide required water supply, compressed air, sprinkler, and drain piping. Terminate drain piping over a funnel floor drain.
- 3.14.4 Provide detection devices and install in accordance with manufacturer's instructions. Connect to control panel with wiring in conduit.
- 3.14.5 Supply detection devices and hand to electrical trade on site for installation.
- 3.14.6 Include for 4 hours of on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.15 **INSTALLATION OF ZONE CONTROL RISER MODULES**

- 3.15.1 Provide zone control riser modules with drain piping where required. Terminate drainage piping over a funnel floor drain unless otherwise shown or specified. Identify each assembly.

3.16 **INSTALLATION OF ZONE CONTROL RISER MODULE CABINETS**

- 3.16.1 Provide flush wall mounting cabinets for zone control and inspector's test connection assemblies where required in finished areas. Confirm exact locations prior to roughing-in.
- 3.16.2 Identify each cabinet with a nameplate in accordance with requirements of Section 20 05 00 – Common Work Results for Mechanical.

3.17 **INSTALLATION OF SPRINKLER HEADS**

- 3.17.1 Provide required sprinkler heads in accordance with following schedule:

Application	Sprinkler HEAD TYPE
Healthcare Facility Type I rooms/areas as per CAN/CSA-Z317.2, Table 1, HVAC Design Criteria, first two columns	Victaulic V38/V39 or Tyco Series RFII "Royal Flush II" concealed pendent
Healthcare Facility Type II rooms/area as per CAN/CSA-Z317.2, Table 1, HVAC Design Criteria, first two columns	Victaulic V27 or Tyco Series TY-FRB recessed pendent
Healthcare Facility Type III rooms/areas as per CAN/CSA-Z317.2, Table 1, HVAC Design Criteria, first two columns	Victaulic V27 or Tyco Series TY-FRB recessed pendent
Healthcare patient unit without a suspended ceiling but with a ceiling bulkhead	Victaulic V27 or Tyco Series TY-FRB recessed horizontal sidewall Victaulic V38/V39 or Tyco Series RFII "Royal Flush II" concealed pendent or Victaulic V27 or Tyco Series TY-FRB recessed pendent in bottom of bulkhead if bulkhead is greater than 200 mm (8") deep
Healthcare Facility mental health room/areas	Tyco "RAVEN" institutional, tamper-resistant pendent or horizontal sidewall as required
Healthcare Facility MRI Suite	Reliable Model F4FR-NF non-ferrous concealed pendent

Application	Sprinkler HEAD TYPE
Rooms/areas with a suspended ceiling	Victaulic V38/V39 or Tyco Series RFI "Royal Flush II" concealed pendent Victaulic V27 or Tyco Series TY-FRB recessed pendent Victaulic V27 or Tyco Series TY-FRB pendent with escutcheon plates
Rooms/areas without a suspended ceiling	Victaulic V27 or Tyco Series TY-FRB pendent
Elevator shafts	Victaulic V27 or Tyco Series TY-FRB horizontal sidewall
Unheated exterior stairwells	Victaulic V36 or Tyco Series DS-1 dry pipe horizontal sidewall Victaulic V36 or Tyco Series DS-3 wet pipe horizontal sidewall
Air handling system outdoor air and relief air plenums (unheated)	Tyco Series DS-3 ECOH dry horizontal sidewalls in wet piping Victaulic V27 or Tyco Series TY-FRB upright or horizontal sidewall in dry pipe or anti-freeze piping
Unheated and unfinished areas	Victaulic V36 or Tyco Series DS-3 ECOH dry horizontal sidewall in wet piping Victaulic V27 or Tyco Series TY-FRB upright or horizontal sidewall in dry pipe or anti-freeze piping
Heated areas with overhead doors	Victaulic V27 or Tyco Series TY-FRB horizontal sidewall
Unheated parking garage	Victaulic V34 or Tyco Series EC-11 or EC-14 ECOH upright or Victaulic V27 or Series TY-FRB upright for dry piping
Heated parking garage	Victaulic V34 or Tyco Series EC-11 or EC-14 ECOH upright or Victaulic V27 or Series TY-FRB upright for wet piping
Parking garage ramp	Victaulic V34 or Tyco Series EC-11 or EC-14 ECOH upright or Series TY-FRB upright or Victaulic V27 or Series ELO SW-20 or SW-24 ECOH sidewall
At non-rated windows in rated walls	Tyco Model WS horizontal and pendent vertical sidewall

- 3.17.2 Sprinkler head manufacturers indicated on schedule are for type indication purposes. Manufacturers are listed in Part 2 of this Section.
- 3.17.3 Provide quick response type sprinkler heads for healthcare facilities.
- 3.17.4 Coordinate sprinkler head locations with all drawings, including architectural reflected ceiling plan drawings, and, where applicable, electrical drawings. Coordinate sprinkler head locations in areas with suspended ceilings with the location of lighting, grilles, diffusers, and similar items recessed in or surface mounted on the ceiling as per the reflected ceiling plans. In areas with lay-in tile, centre the sprinkler head both ways in the lay-in tile wherever possible. Confirm locations prior to roughing-in.
- 3.17.5 Maintain maximum headroom in areas with no ceilings.
- 3.17.6 Provide guards for heads where they are subject to damage.
- 3.17.7 Provide high temperature heads in equipment rooms and similar areas over heat producing or generating equipment.

3.18 *INSTALLATION OF SPARE SPRINKLER HEAD CABINETS*

- 3.18.1 Supply a full complement (to fill cabinet) of spare sprinkler heads of types used (minimum 4 of each type) and place in a wall mounting storage cabinet located adjacent to sprinkler system "head end" equipment where later directed.

3.19 *INSTALLATION OF INDICATOR POST VALVES*

- 3.19.1 Provide a shut-off valve in underground sprinkler main piping outside building. Equip valve with a valve box and an indicator post assembly.
- 3.19.2 Confirm valve box length and steel shaft length prior to ordering and confirm exact location prior to roughing-in.
- 3.19.3 When installation is complete, check and test operation of assembly and adjust as required.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for all products specified in Part 2 of this section except pipe and fittings.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit a copy of the plumbing inspection certificate prior to application for Substantial Performance of the Work.
- 1.2.2 Submit laboratory water purity test results indicating chlorine residual prior to application for Substantial Performance of the Work.
- 1.2.3 Record Documentation
 - 1.2.3.1 Retain services of a land surveyor, registered in jurisdiction of the work, to maintain an accurate record of all underground site services. Surveyor is to measure, verify and record size, location, invert elevation, pipe material, and slope of site service piping and connected products on site.
 - 1.2.3.2 When site services work is complete, surveyor is to prepare an original signed and sealed drawing, using same size and format as Contract Drawings, indicating all site services as-built information. Submit a copy of drawing to the Consultant. Include this drawing with Contract as-built record drawings.

1.3 SOILS TEST REPORT

- 1.3.1 Carefully examine soils test report and include for requirements applicable as a result of the report.

2 PRODUCTS

2.1 PIPE, FITTINGS, AND JOINTS

- 2.1.1 Concrete
 - 2.1.1.1 Circular bell and spigot pattern pipe and fittings with rubber gasket joints to CAN/CSA A257 Series, produced by a member of Ontario Concrete Pipe Association in a plant which is currently approved under O.C.P.A. Plant Pre-qualification Program. Pipe less than or equal to 375 mm (15") dia. is to be non-reinforced Class 3. Pipe greater than 375 mm (15") dia. is to be reinforced Class III.
- 2.1.2 PVC Sewer
 - 2.1.2.1 DR35 rigid, green PVC hub and spigot pattern sewer pipe and fittings to CAN/CSA B182.2, with gasket joints assembled with pipe lubricant.
- 2.1.3 PVC Water Service
 - 2.1.3.1 ULC listed, rigid, Class 150, DR18, 1035 kPa (150 psi) pressure rated bell and spigot pattern PVC pipe to CAN/CSA B137.3, and CSA certified fittings to CAN/CSA B137.2, and AWWA C900, complete with gasket joints, and Ford "Uni-Flange" or equal restraint collars in accordance with Part 3 of this section.
- 2.1.4 Soft Copper Water Service
 - 2.1.4.1 Type "K" soft copper to ASTM B88, supplied in a continuous coil with no joints if possible, and complete with, if joints are required, compression type flared joint couplings.
- 2.1.5 Flexible Polyethylene

- 2.1.5.1 Flexible polyethylene pipe to CAN/CSA B137.1, 690 kPa (100 psi) rated, complete with insertion type fittings secured with Series 300 stainless steel gear type clamps.
- 2.1.6 Perforated Weeper Drainage Piping
 - 2.1.6.1 Flexible, 150 mm (6") dia. PVC perforated piping supplied in rolls and complete with a geodesic sock.

2.2 CATCH BASINS

- 2.2.1 Pre-cast, water-tight reinforced concrete catch basins manufactured to ASTM C478 and Municipal standards, each sized and arranged to suit drainage pipe size and arrangement, and complete with:
 - 2.2.1.1 cast iron frame and cover to Municipal standards;
 - 2.2.1.2 required masonry work to raise top of catch basins flush with finished grade or pavement surfaces.
- 2.2.2 Masonry work is to consist of cement mortar and clay or shale bricks to ASTM C32 Grade M5, or Oaks Precast Industries "MODULOC" or equal pre-cast interlocking concrete members and accessories.

2.3 MANHOLES

- 2.3.1 Pre-cast, water-tight reinforced concrete manholes manufactured to ASTM C478 and Municipal standards, each sized and arranged to suit drainage pipe size and arrangement, and complete with:
 - 2.3.1.1 poured-in-place or pre-cast concrete base;
 - 2.3.1.2 cast-in-place "Safety" type aluminum steps on 300 mm (12") centres, each step coated with 2 coats of static asphalt paint;
 - 2.3.1.3 unperforated cast iron cover with lifting holes, and a matching frame;
 - 2.3.1.4 as required by manhole depth and safety regulations, cast-in-place hinged aluminum safety grating with SG 1 1 R-T6 aluminum alloy bearing bars, aluminum grate to CAN/CSA S157, and self-locking type stainless steel hinges and fasteners with galvanized steel safety chain and snap hook;
 - 2.3.1.5 required masonry work to raise top of manholes flush with finished grade.
- 2.3.2 Masonry work is to consist of cement mortar and clay or shale bricks to ASTM C32 grade M5, or Oaks Precast Industries "MODULOC" or equal pre-cast interlocking concrete members and accessories.

2.4 WATER METER CHAMBER

- 2.4.1 Pre-cast, water-tight reinforced concrete chamber manufactured to ASTM C478 and Municipal standards, each sized and arranged as shown and complete with:
 - 2.4.1.1 poured-in-place or pre-cast concrete base with a drain hole;
 - 2.4.1.2 cast-in-place "Safety" type aluminum steps on 300 mm (12") centres, each step coated with 2 coats of static asphalt paint;
 - 2.4.1.3 unperforated cast iron cover with lifting holes, and a matching frame;
 - 2.4.1.4 as required by chamber depth and safety regulations, cast-in-place hinged aluminum safety grating with SG 1 1 R-T6 aluminum alloy bearing bars, aluminum grate to CAN/CSA S157, and self-locking type stainless steel hinges and fasteners with galvanized steel safety chain and snap hook;
 - 2.4.1.5 required masonry work to raise top of chamber flush with finished grade.
 - 2.4.2 Masonry work is to consist of cement mortar and clay or shale bricks to ASTM C32 grade M5, or Oaks Precast Industries "MODULOC" or equal pre-cast interlocking concrete members and accessories.
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2.5 WATER METER

- 2.5.1 Equal to Neptune Technologies Group (Canada) Ltd. "Neptune High Performance Turbine" tamper-proof, in-line serviceable meter suitable for connection of a remote automatic reading and billing unit and complete with a cast bronze main case, a roll-sealed magnetic drive register, and a turbine measuring element.
- 2.5.2 Equip meter with a Neptune Technologies Group (Canada) Ltd. or equal "ARB-V" surface wall mounting automatic meter reading and billing unit with encoder register, polycarbonate housing, roll-sealed copper shell, and ABS plastic receptacle.
- 2.5.3 Equip meter with Neptune Technologies (Canada) Ltd. or equal "Tricon" hardware for interface connection to building automation system for water flow and consumption monitoring.

2.6 WATER METER VALVES

- 2.6.1 Shut-Off Valves
 - 2.6.1.1 Non-corrosive, minimum 1200 kPa (175 psi) cold water pressure rated, resilient seated, flanged butterfly valves, each complete with a coated cast iron lug type body, stainless steel shaft, bronze disc, and EPDM seat, and each suitable for domestic water bubble-tight dead end service with valve in position and either side of connecting piping removed. Equip butterfly valves less than or equal to 100 mm (4") dia. with lever handles. Equip butterfly valves greater than 100 mm (4") dia. with worm gear operators.
 - 2.6.1.2 Manufacturers:
 - (1) DeZurik #632L Series;
 - (2) Bray Valve and Controls Canada Series 34;
 - (3) Apollo Valves #143 Series;
 - (4) Centerline #L2000L or #G200L depending on size;
 - (5) Watts Industries (Canada) Inc. #BF-03.
- 2.6.2 Check Valve
 - 2.6.2.1 Class 125, non-corrosive, 1380 kPa (200 psi) WOG rated horizontal swing type check valves, each approved for domestic water service and complete with flanged ends.
 - 2.6.2.2 Manufacturers:
 - (1) Toyo Valve Co.;
 - (2) Milwaukee Valve Co.;
 - (3) Kitz Corporation;
 - (4) Apollo Valves.

2.7 FIRE HYDRANTS

- 2.7.1 FM approved and ULC listed, compression type, dry top, non-freeze hydrants manufactured to meet or exceed requirements of AWWA C502, designed for a 1035 kPa (150 psi) service pressure and a hydrostatic test pressure of 2070 kPa (300 psi), and complete with:
 - 2.7.1.1 flanged intermediate section painted with a bituminous black coating, and with a length to suit depth of underground water main;
 - 2.7.1.2 Two 65 mm (2-½") dia. hose connections, each with a cap and chain and threaded to CSA B89.2 (Ontario thread) to suit local Fire Department and pumper connection requirements;

- 2.7.1.3 operating nut which opens in a counter-clockwise direction and a 140 mm (5- $\frac{1}{2}$ ") dia. compression type main valve;
- 2.7.1.4 bronze to bronze interface between removable parts of main valve assembly and hydrant body;
- 2.7.1.5 hydrant barrel complete with breakaway section at ground line, with exposed bolts and nuts of rust and corrosion resistant alloy;
- 2.7.1.6 150 mm (6") dia. elbow inlet connection to suit underground piping;
- 2.7.1.7 2 coats of weatherproof enamel with colour(s) to local Municipal requirements.
- 2.7.2 Manufacturers:
 - 2.7.2.1 Clow Canada;
 - 2.7.2.2 Mueller Canada "Century".

2.8 FIRE HYDRANT SHUT-OFF VALVES

- 2.8.1 Resilient seated, 1380 kPa (200 psi) rated, non-rising stem, FM approved and ULC listed wedge gate valves to AWWA C509, each with hub ends suitable for mechanical joint pipe connection, and an adjustable cast iron valve box (length to suit) with cover.
- 2.8.2 Manufacturers:
 - 2.8.2.1 Clow Canada #F6100 Series valve with box and cover;
 - 2.8.2.2 Mueller #2360 Series with box and cover.

3 EXECUTION

3.1 UNDERGROUND MUNICIPAL SERVICE CONNECTIONS

- 3.1.1 Make required arrangements with Municipality for installation of underground service piping from Municipal main(s) to property line.
- 3.1.2 Pay charges levied by Municipality for service connection work.
- 3.1.3 Municipal charges for underground street service connection work will be paid out of a prime cost allowance. Submit original copies of invoices issued by Municipality for street service connection work.

3.2 EXCAVATION AND BACKFILL

- 3.2.1 Refer to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, and Section 31 23 00 – Excavation and Backfill.
 - 3.2.2 Locate general reference points and take necessary precautions to prevent damage or destruction to these points. Be responsible for site services work lines, elevations and measurements.
 - 3.2.3 Ensure locations of existing underground services, mechanical and electrical, are properly and accurately located and marked. Be responsible for any damage to existing services caused as a result of site services work.
 - 3.2.4 Excavate to a minimum of 150 mm (6") below bottom of pipe. Support pipe, unless otherwise specified, on a well compacted bed of dry, natural, undisturbed earth free from rocks or protrusions of any kind, or on compacted sand or granular B material as specified.
 - 3.2.5 Where unstable soil is present at bottom of trench, provide concrete saddles, pies, or other approved and suitable foundations.
 - 3.2.6 Retain and pay for the services of an independent testing agency to test and report on the compaction of backfill. Upon completion, obtain from testing agency and submit to the Consultant a signed and sealed report confirming all specified backfill compaction was achieved at all locations.
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3.3 CONCRETE WORK

- 3.3.1 Provide poured concrete work, including reinforcing and formwork, required for site services work.
- 3.3.2 Concrete is to be minimum 20 700 kPa (3 000 psi) ready-mix concrete in accordance with CAN/CSA A23.1 and the Building Code.

3.4 DRAINAGE SERVICE PIPING INSTALLATION REQUIREMENTS

- 3.4.1 Provide required underground drainage service piping to within 1.5 m (5') of building. Pipe, unless otherwise specified, is to be concrete or rigid PVC sewer pipe.
- 3.4.2 Install and slope underground drainage piping to inverts or slopes indicated on drawings to facilitate straight and true gradients between points shown. Verify available slopes before installing pipes.
- 3.4.3 At the end of each working day temporarily plug and/or cap open piping ends to prevent entry of debris or dirt.

3.5 WEEPER SYSTEM PIPING INSTALLATION REQUIREMENTS

- 3.5.1 Provide sub-soil and building footing weeper system piping.
- 3.5.2 Lay pipe on a 150 mm (6") bed of granular A material, then backfill 150 mm (6") above and around pipe with granular A material. Backfill remainder of trench as specified in this section.

3.6 CONNECTION OF BUILDING WEEPER SYSTEM PIPING

- 3.6.1 Provide piping required to extend building weeper system piping into storm drainage piping system from connection point(s).

3.7 WATER SERVICE PIPING INSTALLATION REQUIREMENTS

- 3.7.1 Provide required underground water service piping to within 1.5 m (5') of building.
- 3.7.2 Piping, unless otherwise specified, is as follows:
 - 3.7.2.1 for service piping greater than or equal to 100 mm (4") dia. - rigid PVC;
 - 3.7.2.2 for service piping less than 100 mm (4") dia. - Type "K" soft copper;
 - 3.7.2.3 for distribution piping to exterior fixtures/outlets at grade level – flexible polyethylene, snaked in trench and in a continuous length wherever possible.
- 3.7.3 Brace and secure underground water service pipe at bends, tees and similar fittings with restraint devices, and provide concrete thrust blocks in accordance with Municipal or Provincial standards and details. Regardless of what is specified elsewhere in this Specification regarding provisions of concrete, provide thrust block concrete. Paint restraint devices with 2 coats of corrosion resistant black asphalt base coating and allow time to dry prior to backfilling.
- 3.7.4 Lay pipes true to line and grade with bells up grade. Fit sections together so, when complete, pipe has a smooth and uniform invert. Keep pipe thoroughly clean so jointed compound will adhere. Inspect pipe for defects before being lowered into trench.
- 3.7.5 Slope piping so it can be completely drained.
- 3.7.6 At the end of each working day, temporarily plug and/or cap all open piping ends to prevent entry of debris or dirt.

3.8 INSTALLATION OF MANHOLES

- 3.8.1 Provide pre-cast concrete manholes. Properly bed each unit and set to required invert.
-

- 3.8.2 Provide a reinforced pre-cast concrete base slab and bottom section for each manhole, or provide a poured-in-place concrete base. Ensure each manhole is sized to suit pipe size and arrangement. Conform to Municipal installation standards.
- 3.8.3 Perform masonry work required to raise top of each assembly flush with finished grade level.
- 3.8.4 When work is substantially complete, clean out each manhole.

3.9 INSTALLATION OF CATCH BASINS

- 3.9.1 Provide pre-cast concrete catch basins. Properly bed each unit and set to required invert.
- 3.9.2 Ensure each catch basin is sized to suit pipe size and arrangement. Conform to Municipal installation standards.
- 3.9.3 Perform masonry work required to raise top of each assembly flush with finished grade level.
- 3.9.4 When work is substantially complete, clean out each catch basin.

3.10 INSTALLATION OF WATER METER CHAMBER

- 3.10.1 Provide a pre-cast concrete water meter chamber. Properly bed unit and set to required invert. Ensure base drain hole is placed over a granular A material soak-away area.
- 3.10.2 Provide a reinforced pre-cast concrete base slab and bottom section for chamber. Ensure each chamber is properly sized and conforms to Municipal installation standards.
- 3.10.3 Perform masonry work required to raise top of assembly flush with finished grade level.
- 3.10.4 Provide PVC conduit with pull boxes as required and conductors from chamber to building for meter reading/BAS connections. Terminate conductors in a junction box.
- 3.10.5 When work is substantially complete, clean out chamber.

3.11 SUPPLY OF WATER METER

- 3.11.1 Supply domestic water service meter and hand (inside meter room) to trade installing the meter.

3.12 INSTALLATION OF WATER METER

- 3.12.1 Provide domestic water service meter in meter pit. Secure meter in place on a concrete housekeeping pad and connect with piping, including a 3-valve bypass.
- 3.12.2 Refer to drawing detail.

3.13 INSTALLATION OF FIRE HYDRANTS

- 3.13.1 Provide fire hydrants. Confirm exact locations and orientations prior to roughing-in.
 - 3.13.2 Equip each hydrant with a shut-off valve and connect with piping. Piping is to be rigid PVC.
 - 3.13.3 Conform to Municipal installation standards, including provision of concrete thrust blocks at piping elbows and similar fittings.
 - 3.13.4 Set each valve box cover flush with finished grade in a formed 300 mm x 300 mm x 100 mm (12" x 12" x 4") thick concrete pad with a sack rubbed finish.
 - 3.13.5 Regardless of what is specified elsewhere in this Specification regarding provision of concrete, provide thrust block and valve box pad concrete.
 - 3.13.6 When installation is complete, remove hydrant nozzle caps and fully open to completely flush assembly and test operation.
 - 3.13.7 Touch-up paint any damaged hydrant finish.
-

3.14 TESTING AND INSPECTION OF SERVICES

- 3.14.1 Prior to backfilling, test new service piping for leakage and flow in the presence of the Consultant and Plumbing Inspector. Give a minimum of 72 hours notice for scheduled tests.
- 3.14.2 Drainage Piping Leakage
 - 3.14.2.1 Perform infiltration or exfiltration tests on drainage piping as directed by the Consultant with leakage not to exceed values issued by the Consultant. Where leakage exceeds values issued, refit piping, and re-apply tests until acceptable results are obtained.
- 3.14.3 Drainage Piping Flow
 - 3.14.3.1 When directed by the Consultant and/or Plumbing Inspector, perform ball flow tests on all drainage piping.
- 3.14.4 Water Mains Leakage
 - 3.14.4.1 Leakage test new water mains using clean water at 1400 kPa (200 psi) for a minimum period of 8 hours with no pressure drop.

3.15 FLUSHING AND DISINFECTING WATER SERVICE PIPING

- 3.15.1 Thoroughly flush domestic water service piping after leakage and flow testing is complete.
- 3.15.2 Flush piping with clean water at a minimum velocity of 1.2 m/s (240 ft/min) at 205 kPa (30 psi) minimum pressure until all foreign materials have been removed and flushed water is clear. Provide connections and pumps as required.
- 3.15.3 When flushing is complete, disinfect piping with a solution of chlorine in accordance with AWWA C601.
- 3.15.4 When disinfecting is complete, submit water samples to a certified laboratory for purity testing and, when testing indicates pure water in accordance with governing standards, submit a copy of test results and fill systems.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 The purpose of this section is to specify Division 22 responsibilities in the commissioning process.
- 1.1.2 Commissioning requires the participation of Division 22 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 13. Division 22 shall be familiar with all parts of Section 01 91 13 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 REFERENCES

- 1.2.1 2015 ASHRAE Handbook – HVAC Applications Chapter 43 HVAC Commissioning.
- 1.2.2 ASHRAE Guideline 1.1 – 2007 – The HVAC&R Technical Requirements for the Commissioning Process.
- 1.2.3 ASHRAE Guideline 0 – 2013 – The Commissioning Process.
- 1.2.4 ASHRAE 202 – 2013 – Commissioning Process for Buildings and Systems.
- 1.2.5 ASHRAE Guideline 4-2008 – Preparation of O&M Documentation.
- 1.2.6 CSA Z320-11 (R2021) Building Commissioning Standard & Check Sheets.
- 1.2.7 CSA C282-15 – Emergency Power Supply for Buildings.

1.3 SUBMITTALS

- 1.3.1 Division 22 Contractors shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 01 91 13, Article “Submittals” for additional Division 22 requirements.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Written work products of Division 22 contractors will consist of the startup and initial checkout plan as described in Section 01 91 13, as well as completed startup, initial checkout, and pre-functional test sheets.

1.5 OPERATIONS AND MAINTENANCE DATA

- 1.5.1 Division 22 Contractors shall compile and prepare documentation for all equipment and systems covered in Division 22 and deliver to the GC for inclusion in the O&M manuals.
- 1.5.2 ASHRAE Guideline 4-2008 is the recommended format.
- 1.5.3 The CxA shall receive a copy of the O&M manuals for review.

1.6 SYSTEMS TO BE COMMISSIONED

- 1.6.1 The following plumbing work shall be commissioned as part of this contract:
 - 1.6.1.1 Domestic Cold Water supply systems.
 - 1.6.1.2 Domestic Hot Water supply systems.
 - 1.6.1.3 Domestic Hot Water Recirculation systems.

1.7 COMMISSIONING TEAM

- 1.7.1 The Commissioning Team shall consist of representatives of the following:
 - 1.7.1.1 Owner and the Owner's Operating and Maintenance Staff.
 - 1.7.1.2 Architect.
 - 1.7.1.3 Mechanical Design Engineer.
-

- 1.7.1.4 Commissioning Agent (CxA).
- 1.7.1.5 General Contractor.
- 1.7.1.6 Mechanical Contractor – Plumbing.
- 1.7.1.7 Controls Sub-Contractor.
- 1.7.1.8 Electrical Sub-Contractor.
- 1.7.1.9 Testing, Adjusting, and Balancing Agency.

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 COMMISSIONING AGENT RESPONSIBILITIES

- 3.1.1 The Commissioning Agent shall be responsible for the following:
 - 3.1.1.1 Plan, organize and implement the commissioning process as specified herein.
 - 3.1.1.2 Prepare the commissioning plan, ensure its distribution for review and comment.
 - 3.1.1.3 Revise the commissioning plan as required during construction.
 - 3.1.1.4 Chair commissioning meetings and prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting.
 - 3.1.1.5 In conjunction with the GC and trades coordinate commissioning activities.
 - 3.1.1.6 Monitor system verification checks, and ensure the results are documented as the checks are done.
 - 3.1.1.7 Observe select start-ups and initial system operations tests and checks.
 - 3.1.1.8 Direct GC and trades to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes.
 - 3.1.1.9 Witness functional performance tests and document the results.
 - 3.1.1.10 Prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each.
 - 3.1.1.11 Ensure all required O&M manuals, instructions and demonstrations are provided to the Owner's designated operating staff.

3.2 ENGINEER OF RECORD RESPONSIBILITIES

- 3.2.1 The engineer shall review the Commissioning Plan and will participate, as appropriate, in on-site commissioning meetings.
- 3.2.2 At their discretion during the acceptance phase of the commissioning process, be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- 3.3.1 The Owner shall have the following commissioning responsibilities:
- 3.3.2 Ensure the availability of operating staff for all scheduled instructions and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.

3.4 PLUMBING CONTRACTOR RESPONSIBILITIES

- 3.4.1 The responsibilities of the Plumbing Contractor, during construction and acceptance phases in addition to those listed above are (all references apply to commissioned equipment only):
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- 3.4.1.1 Documentation of all procedures performed shall be provided and forwarded to the Engineer of Record. Written documentation must contain recorded test values of all tests performed per the individual product specification.
 - 3.4.1.2 The start-up service company shall be present during energization of the plumbing equipment. Jobsite and equipment access must be provided by the Plumbing Contractor.
 - 3.4.1.3 The contractor shall supply a power source, specified by the start-up service company, for on-site test equipment.
 - 3.4.1.4 The Plumbing Contractor is to attend all factory witness testing required within the respective specification sections. The contractor is responsible to cover all their costs and include them in their bid.
 - 3.4.1.5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
 - 3.4.1.6 Include the cost of commissioning in the contract price, if not yet included.
 - 3.4.1.7 In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.
 - 3.4.1.8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process.
 - 3.4.1.9 Contractors shall provide normal cut sheets and shop drawing submittals to the CxA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of pre-functional and functional testing procedures.
 - (1) Typically, this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
 - (2) The Commissioning Agent may request further documentation necessary for the commissioning process. This data request may be made prior to normal submittals.
 - 3.4.1.10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CxA for review.
 - 3.4.1.11 Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 - 3.4.1.12 Provide assistance to the CxA in preparation of the specific functional performance test procedures specified in Division 22. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
 - 3.4.1.13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CxA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CxA for review.
 - 3.4.1.14 During the startup and checkout process, execute and document the mechanical-related portions of the pre-functional test sheets provided by the CxA for all commissioned equipment.
 - 3.4.1.15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
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- 3.4.1.16 Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
- 3.4.1.17 Perform functional performance testing under the direction of the CxA for specified equipment to be commissioned. Assist the CxA in interpreting the monitoring data, as necessary.
- 3.4.1.18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, PM and A/E and retest the equipment.
- 3.4.1.19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- 3.4.1.20 During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for contractor-generated coordination drawings.
- 3.4.1.21 Provide training of the Owner's operating personnel as specified.
- 3.4.1.22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- 3.4.1.23 Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.
- 3.4.1.24 Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
- 3.4.1.25 Assist and cooperate with the Mechanical and TAB contractor and CxA by:
 - (1) Putting all equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
 - (2) Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.
- 3.4.1.26 Install a P/T plug at each water sensor which is an input point to the control system.
- 3.4.1.27 List and clearly identify on the as-built drawings the locations of applicable sensors and meters.
- 3.4.1.28 Prepare a preliminary schedule, in conjunction with Division 25 Contractors for Division 22 pipe system testing, flushing, and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.
- 3.4.1.29 Notify the PM/GC or CxA depending on protocol, when pipe system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the PM/GC or CxA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CxA has the scheduling information needed to efficiently execute the commissioning process.

3.5 SYSTEM STARTUP

- 3.5.1 The plumbing contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 13. Division 22 has start-up responsibility and is required to complete systems and sub-systems, so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.
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- 3.5.2 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- 3.5.3 Prior to the start up of equipment the Division 22 Contractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- 3.5.4 The Supplier shall submit a written report of their findings.
- 3.5.5 Upon confirmation that the equipment has been installed in accordance with the manufacturers' recommendations the equipment may be started.
- 3.5.6 All equipment shall be started by the manufacturer's representative.

3.6 PRE-FUNCTIONAL TEST SHEETS

- 3.6.1 Pre-functional test sheets contain items for Division 22 Contractors to perform. On each checklist, a column is provided that is to be completed by the contractor assigning responsibility for that line item to a trade. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- 3.6.2 Refer to Section 01 91 13 for additional requirements regarding pre-functional test sheets, startup, and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CxA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = all Contractors, CxA = Commissioning Agent, CC = Controls Contractor, EC = Electrical Contractor, PM/GC = General Contractor, MC = Mechanical Contractor, SC = Sheet Metal Contractor, TAB = Test and Balance Contractor.

3.7 TRAINING

- 3.7.1 The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 13 for additional details.
- 3.7.2 The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01 91 13 for additional details.
- 3.7.3 Plumbing Contractor. The Plumbing Contractor shall have the following training responsibilities:
 - 3.7.3.1 Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 13, Article "Training".
 - 3.7.3.2 Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of plumbing equipment.
 - 3.7.3.3 Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

- 3.7.3.4 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary, and the demonstration repeated.
- 3.7.3.5 The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
- 3.7.3.6 The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
- 3.7.3.7 The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
- 3.7.3.8 Training shall include:
 - (1) Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - (2) A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - (3) Discussion of relevant health and safety issues and concerns.
 - (4) Discussion of warranties and guarantees.
 - (5) Common troubleshooting problems and solutions.
 - (6) Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
 - (7) Discussion of any peculiarities of equipment installation or operation.
- 3.7.3.9 The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1, latest edition.
- 3.7.3.10 Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
- 3.7.3.11 Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance for all pieces of equipment.
- 3.7.3.12 The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- 3.7.3.13 Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

3.8 DEFERRED TESTING

- 3.8.1 Refer to Section 01 91 13, Article "Deferred Testing" for requirements of deferred testing.

END OF SECTION

1 GENERAL

1.1 REFERENCES

- 1.1.1 Domestic water piping and valves are to comply with following codes, regulations and standards (as applicable):
 - 1.1.1.1 applicable local codes and regulations;
 - 1.1.1.2 CAN/CSA B125.1, Plumbing Supply Fittings;
 - 1.1.1.3 CAN/CSA B125.3, Plumbing Fittings;
 - 1.1.1.4 CAN/CSA B137 Series, Thermoplastic Pressure Piping Compendium;
 - 1.1.1.5 CAN/CSA B64 Backflow Preventers and Vacuum Breakers
 - 1.1.1.6 NSF/ANSI 14, Plastics Piping System Components and Related Materials;
 - 1.1.1.7 NSF/ANSI 61, Drinking Water System Components – Health Effects;
 - 1.1.1.8 NSF/ANSI 372, Drinking Water System Components – Lead Content.

1.2 SUBMITTALS

- 1.2.1 Submit shop drawings/product data sheets for all products specified in Part 2 of this Section except for pipe, fittings, and chlorine solution.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Submit laboratory water purity test results indicating chlorine residual prior to application for Substantial Performance of the Work.
- 1.3.2 Prior Substantial Performance of the Work, submit a minimum of 3 identified keys for key operated hydrants.
- 1.3.3 Submit signed test results and inspection and test log cards for each backflow preventer as specified in Part 3 of this Section.
- 1.3.4 Submit anchor drawing(s) to detail fabrication and installation of water piping anchors. Drawing(s) are to be prepared and stamped by a professional structural engineer registered and licensed in jurisdiction of the work.
- 1.3.5 As specified in Part 3 of this Section, submit a letter from anchor design engineer stating anchor installation has been examined at site and anchors are properly fabricated and installed.

2 PRODUCTS

2.1 PIPE, FITTINGS, AND JOINTS

- 2.1.1 PVC
 - 2.1.1.1 ULC listed, rigid, Class 150, DR18, 1035 kPa (150 psi) pressure rated bell and spigot pattern PVC pipe to CAN/CSA B137.3, and CSA certified fittings to CAN/CSA B137.2, and AWWA C900, complete with gasket joints, and Ford "Uni-Flange" or equal restraint collars as per Part 3 of this Section.
 - 2.1.2 Soft Copper
 - 2.1.2.1 Type "K" soft copper to ASTM B88, supplied in a continuous coil with no joints if possible, and complete with, if joints are required, compression type flared joint couplings.
 - 2.1.3 Stainless Steel
 - 2.1.3.1 Schedule 10S type 304 stainless steel, ASTM A312, factory or site roll grooved, complete with Victaulic or equal type 304 stainless steel roll grooved end fittings and, unless otherwise specified, Victaulic Style 807, 877 or 889 couplings and coupling gaskets equal to Victaulic Grade P fluoroelastomer.
 - 2.1.4 Copper - Solder Joint
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- 2.1.4.1 Type "L" hard drawn seamless copper to ASTM B88, complete with copper solder type fittings to ASME/ANSI B16.18 and soldered joints using The Canada Metal Co. Ltd. "SILVABRITE 100" or equal lead-free solder for cold water pipe, and 95% tin / 5% Antimony or "SILVABRITE 100" solder for other services.
- 2.1.5 Copper - Pressure Coupled Joint
 - 2.1.5.1 Type "L" hard drawn seamless copper to ASTM B88 with Viega "ProPress with Smart Connect feature" copper fittings with EDPM seals, and pressure type crimped joints made by use of manufacturer recommended tool.
- 2.1.6 Copper - Grooved
 - 2.1.6.1 Type "L" hard drawn seamless copper to ASTM B88 with Victaulic QuickVic Style 607 non-reducing, bolted connection type suitable and approved for application intended, 2" - 8" for copper tubing consisting of ductile iron cast housings, complete with a Grade P fluoroelastomer gasket of a pressure-responsive design, with plated nuts and bolts to secure unit together.
- 2.1.7 Semi-Rigid Polyethylene Tubing
 - 2.1.7.1 Versa Fittings and Mfg. Inc. 12 mm (½") dia., high density, semi-rigid polyethylene tubing, 1380 kPa (200 psi) rated.
- 2.1.8 Flexible Polyethylene
 - 2.1.8.1 Flexible polyethylene pipe to CAN/CSA B137.1, 690 kPa (100 psi) rated, complete with insertion type fittings secured with Series 300 stainless steel gear type clamps.
- 2.1.9 Cross-Linked Polyethylene (PEX) Tubing
 - 2.1.9.1 Non-barrier type PEX piping in accordance with CAN/CSA B137.5, ASTM F876 and tested for compliance by an independent third-party agency, 25/50 flame spread/smoke developed rated when tested to CAN/ULC S102.2 and complete with brass inserts and crimp-ring or cold-expansion joint fittings and couplings.

2.2 SHUT-OFF VALVES

- 2.2.1 Ball Valves
 - 2.2.1.1 Class 600, 4140 kPa (600 psi) WOG rated, lead-free, full port ball type valves, each complete with a forged brass body with solder ends, forged brass cap, blowout-proof stem, 304 stainless steel ball, "Teflon" or "PTFE" seat, and a removable lever handle. Valves in insulated piping are to be complete with stem extensions.
 - 2.2.1.2 Manufacturers:
 - (1) Toyo Valve Co.
 - (2) Milwaukee Valve Co.
 - (3) Kitz Corporation Code
 - (4) Apollo Valves
 - (5) Watts Industries (Canada) Inc.
 - 2.2.2 Butterfly Valves - Flanged Joint
 - 2.2.2.1 Non-corrosive, minimum 1200 kPa (175 psi) cold water pressure rated, resilient seated butterfly valves, each complete with a coated cast ductile iron lug type body, stainless steel shaft, bronze disc, and EPDM seat, and each suitable for domestic water bubble-tight dead end service with valve in position and either side of connecting piping removed. Butterfly valves to and including 100 mm (4") dia. are to be equipped with lever handles. Butterfly valves larger than 100 mm (4") dia. are to be equipped with worm gear operators.
 - 2.2.2.2 Manufacturers:
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- (1) DeZurik #632L Series;
- (2) Kitz Corporation Code #6122EL/EG;
- (3) Toyo Valve Co. #918BESL/EG;
- (4) Bray Valve and Controls Canada Series 31;
- (5) Apollo Valves #141 Series;
- (6) Watts Industries (Canada) Inc. #BF-03.

2.2.3 Butterfly Valves – Grooved End

- 2.2.3.1 Equal to Victaulic Series 608N, for copper pipe rated to 300 psi and be both bi-directional and dead-end service capable to full rated pressure. Seat material shall be EPDM UL Classified in accordance with ANSI/NSF 61 for ambient +86°F and hot +180°F potable water service and ANSI/NSF 372.
- 2.2.3.2 Victaulic Series 461, for stainless steel pipe rated to 300 psi and be both bi-directional and dead-end service capable to full rated pressure. Seat material shall be EPDM UL Classified in accordance with ANSI/NSF 61 for ambient +86°F and hot +180°F potable water service and ANSI/NSF 372.

2.3 CHECK VALVES

2.3.1 Horizontal

- 2.3.1.1 Lead-free, Class 125, bronze, 1380 kPa (200 psi) WOG rated horizontal swing type check valves with solder ends.
- 2.3.1.2 Manufacturers:
 - (1) Toyo Valve Co. Fig. 237A-LF;
 - (2) Milwaukee Valve Co. #UP1509;
 - (3) Kitz Corporation Code 823;
 - (4) Apollo Valves #61LF Series.

2.3.2 Vertical

- 2.3.2.1 Equal to Kitz Corp. Code 826, lead-free, 1725 kPa (250 psi) WOG rated vertical lift check valve with soldering ends.

2.4 DRAIN VALVES

- 2.4.1 Minimum 2070 kPa (300 psi) water rated, 20 mm (¾") dia., straight pattern full port bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm (¾") dia. garden hose, and a cap and chain. Ball material to be 304 stainless steel.
- 2.4.2 Manufacturers:
 - 2.4.2.1 Toyo Valve Co.
 - 2.4.2.2 Dahl Brothers Canada Ltd.
 - 2.4.2.3 Kitz Corporation
 - 2.4.2.4 Apollo Valves
 - 2.4.2.5 Watts Industries (Canada) Inc.

2.5 DOMESTIC HOT WATER PIPING BALANCING VALVES

- 2.5.1 Equal to Victaulic Series 76X Low Lead Balancing Valve, lead-free and compliant with NSF-61 and NSF-372 for use in potable water applications, automatic flow limiting balancing valve (+/-5% over rated operating pressure range), complete with removable flow cartridge.
 - 2.5.2 Equal to Victaulic TA Series 78BL, solder or flange end type as required, ball valve style, lead-free and compliant with NSF-61 and NSF-372 for use in potable water applications,
-

circuit balancing valves designed to facilitate precise flow measurement, precision flow balancing, and positive shut-off, complete with capped and valved drain connection, and valved ports for connection to a differential pressure meter.

2.6 PARTITION STOPS

- 2.6.1 Equal to Dahl Brothers Canada Ltd. Fig. E2300 Series or equal lead-free partition stops with EDPM packing, slotted spindles, extension tubes, stainless steel access plates, and 3 identified keys.

2.7 PRESSURE REDUCING VALVES

- 2.7.1 For piping less than or equal to 50 mm (2") diameter, lead-free, non-corrosive, non-ferrous direct spring acting pressure reducing valves to CAN/CSA B356, each factory set at 345 kPa (50 psi) unless otherwise specified or required, each field adjustable from 175 kPa (25 psi) to 520 kPa (75 psi) and each complete with an integral inlet strainer.

2.7.1.1 Manufacturers:

- (1) Apollo Valves #36HLF Series;
- (2) Zurn/Wilkins #600XL Series;
- (3) Watts Industries (Canada) Inc. #LF25AUB-Z3 Series;
- (4) Cash-Acme EB-25 Series;
- (5) Bermad Series 935-H

- 2.7.2 For piping greater than or equal to 65 mm (2-½") diameter, lead-free, non-corrosive pilot operated pressure reducing valve to CAN/CSA B356, factory set at required pressure, field adjustable, and complete with a bronze body and trim, screwed or flanged connections, and brass body pilot valve with stainless steel seat.

2.7.2.1 Manufacturers:

- (1) Singer Valve #106 PR;
- (2) Zurn/Wilkins #ZW209;
- (3) Watts Industries (Canada) Inc. #LFN223 Series;
- (4) Bermad Series 972.

2.8 DOMESTIC HOT WATER THERMOSTATIC MIXING VALVES

- 2.8.1 Lawler Manufacturing Co. Inc. 800 Series "High-Low Thermostatic Mixer" factory assembled rough bronze thermostatic mixing valve assembly complete with rotatable union end inlet piping with check stops and stainless steel strainer screens, union outlet piping with thermometer connection, all sized as shown, and following:

- 2.8.1.1 mixing valve with liquid motor, stainless steel piston and liner, tamper-resistant control adjustment, and 3-way protection against runaway temperatures, thermal shock, and scalding;

- 2.8.1.2 dial type thermometer conforming to requirement specified in Section 20 05 00 – Common Work Results for Mechanical;

- 2.8.1.3 ball type outlet shut-off valve conforming to valve requirements specified in this section;

- 2.8.1.4 surface wall mounting enamelled steel cabinet with hinged door, key lock, and permanent identification;

- 2.8.1.5 recessed wall mounting type 304 stainless steel cabinet with a #4 finish, hinged door, key lock, and permanent identification.

2.8.2 Manufacturers:

- 2.8.2.1 Lawler Manufacturing Co. Inc.;
 - 2.8.2.2 Leonard Valve Co.;
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2.8.2.3 Symmons Industries Inc.

2.9 CHLORINE

2.9.1 Sodium hypochlorite to AWWA B300.

2.10 WATER METER

- 2.10.1 Equal to Neptune Technology Group (Canada) Ltd. "Neptune T-10" tamper-proof, in line serviceable meter in accordance with requirements of AWWA C701 and NSF/ANSI 61, suitable for connection of a remote automatic reading and billing unit and complete with a cast bronze main case, a roll sealed register, and a positive displacement nutating disc measuring chamber.
- 2.10.2 Equal to Neptune Technology Group (Canada) Ltd. "Neptune High Performance Turbine" tamper-proof, in-line serviceable meter in accordance with requirements of AWWA C701 and NSF/ANSI 61, suitable for connection of a remote automatic reading and billing unit and complete with a cast bronze main case, a roll-sealed magnetic drive register, and a turbine measuring element.
- 2.10.3 Equip meter with a Neptune Technology Group (Canada) Ltd. or equal "ARB-V" surface wall mounting automatic meter reading and billing unit with encoder register, polycarbonate housing, roll-sealed copper shell, and ABS plastic receptacle.
- 2.10.4 Meter is also to be complete with Neptune Technology (Canada) Ltd. or equal "Tricon" hardware for interface connection to building automation system for water flow and consumption monitoring.

2.11 INTERIOR HOSE BIBBS

- 2.11.1 Flush-Concealed
 - 2.11.1.1 Recessed, 92 mm (3-5/8") deep, recessed, encased wall hydrant with lockable bronze or stainless steel box with hinged cover identified "WATER", bronze interior parts, a screwdriver operated stop in the supply, key operated control valve, 20 mm (¾") dia. hose connection, and a vacuum breaker.
 - 2.11.1.2 Manufacturers:
 - (1) Watts Industries (Canada) Inc. #HY-330.
 - (2) Jay R. Smith #5509QT-CL-SAP;
 - (3) Zurn #Z1350;
 - (4) Mifab #MHY-55;
- 2.11.2 Semi-Recessed - Finished Areas
 - 2.11.2.1 Anti-siphon type, 100 mm (4") deep hose bibb with stainless steel face with operating key, bronze interior parts, 20 mm (¾") dia. solder inlet, 20 mm (¾") dia. hose connection, and integral vacuum breaker.
 - 2.11.2.2 Manufacturers:
 - (1) Watts Industries (Canada) Inc. #HY-430.
 - (2) Jay R. Smith #5619-SAP-98;
 - (3) Zurn #Z1333 "ECOLOTROL";
 - (4) Mifab #MHY-30;
- 2.11.3 Surface – Exposed – Cold Water – Unfinished Areas
 - 2.11.3.1 Brass or bronze hose bibb with hose end vacuum breaker.
 - 2.11.3.2 Manufacturers:
 - (1) Watts Industries (Canada) Inc. #SC8-1;
 - (2) Jay R. Smith #5609QT-SAP.

- (3) Zurn/Wilkins # Z1341 with hose end vacuum breaker;
 - (4) Chicago Faucets #293-E27CP;
 - 2.11.4 Exposed – Unfinished Areas – Hot and Cold Water
 - 2.11.4.1 Mixing faucet for surface mounting.
 - 2.11.4.2 Manufacturers:
 - (1) Watts Industries (Canada) Inc. #HY-300-2-VB.
 - (2) Jay R. Smith #5560QT-LB-SAP;
 - (3) Zurn #Z841L1-RC;
 - (4) Delta Commercial #28T8083;

2.12 EXTERIOR NON-FREEZE WALL HYDRANTS

- 2.12.1 Flush-Concealed
 - 2.12.1.1 Recessed, encased, self-draining hydrants, each complete with a copper casing, operating rod assembly to suit wall thickness, polished nickel bronze box with hinged locking cover, 20 mm ($\frac{3}{4}$ ") dia. threaded hose connection outlet, vacuum breaker, and a loose tee handle operating key.
 - 2.12.1.2 Manufacturers:
 - (1) Watts Industries (Canada) Inc. #HY-725.
 - (2) Jay R. Smith #5519-98;
 - (3) Zurn #Z1320;
 - (4) Mifab #MHY-26;
- 2.12.2 Semi-Recessed
 - 2.12.2.1 Self-draining hydrants, each complete with a copper casing, operating rod assembly to suit the wall thickness, 20 mm ($\frac{3}{4}$ ") dia. threaded hose connection outlet, vacuum breaker, and a loose tee handle operating key.
 - 2.12.2.2 Manufacturers:
 - (1) Watts Industries (Canada) Inc. #HY-420.
 - (2) Jay R. Smith #5619-98;
 - (3) Zurn #Z1321;
 - (4) Mifab #MHY-16;

2.13 EXTERIOR NON-FREEZE GROUND HYDRANTS

- 2.13.1 Flush
 - 2.13.1.1 Flush with grade mounting, encased head, self-draining bronze hydrants, each complete with a casing and operating rod assembly to suit the depth of piping bury, valve housing with drain port, grade box with hinged lockable cover and drain port, 20 mm ($\frac{3}{4}$ ") dia. threaded hose connection, and a loose tee handle operating key.
 - 2.13.1.2 Manufacturers:
 - (1) Watts Industries (Canada) Inc. #HY-500.
 - (2) Jay R. Smith #5810-N-NV;
 - (3) Zurn #Z1360;
 - (4) Mifab #MHY-60;
 - 2.13.2 Exposed
-

2.13.2.1 Self-draining exposed head bronze post hydrants, each complete with a casing and operating rod assembly to suit the height of hose outlet above grade and the depth of piping bury, valve housing with drain port, 20 mm (¾") dia. threaded hose connection assembly with vacuum breaker and gravel guard, and a loose tee handle operating key.

2.13.2.2 Manufacturers:

- (1) Watts Industries (Canada) Inc. #HY-600.
- (2) Jay R. Smith #5910-NV-H;
- (3) Zurn #Z1385;
- (4) Mifab #MHY-65;

2.14 NON-FREEZE ROOF HYDRANT

2.14.1 Woodford Mfg. Model RHY2-MS non-freeze roof hydrant with 25 mm (1") diameter inlet connection, 20 mm (¾") diameter hose end outlet with dual check backflow preventer, a 3.2 mm (1/8") diameter inlet connection drain hole to automatically drain hydrant when shut-off, a mounting system with cast iron support and under deck flange, and required mounting hardware and accessories.

2.15 FLOOR DRAIN TRAP SEAL PRIMERS

2.15.1 Primer Valve Type

2.15.1.1 Precision Plumbing Products Inc. Model P2-500 trap primer valve, constructed of brass, adjustable to high or low water pressures and complete with "O" ring seals, 12 mm (½") threaded inlet and outlet connections, and, for priming two traps from the same primer, a DU-2 dual outlet distribution unit.

2.15.2 Primer Valve Type with Manifold

2.15.2.1 Precision Plumbing Products Inc. Model P1-500 trap primer valve constructed as specified above for the Model P2-500 primer valve, complete with a Model DU-3 or DU-4, 3 or 4 outlet distribution unit for priming 3 or 4 traps, and at Model "YS-8" supply tube with combinations of Model DU-3 and DU-4 distribution units for priming from 5 to 6 traps.

2.15.3 Electronic Type

2.15.3.1 Precision Plumbing Products #PT Series surface wall mounting, CSA certified, 115 V, 1-phase, 60 Hz., electronic, automatic trap priming manifolds, each sized to suit the number of drain traps or interceptors serviced, and each complete with:

- (1) galvanized steel cabinet with door;
- (2) 20 mm (¾") dia. NPT copper pipe inlet with shut-off valve and water hammer arrestor;
- (3) solenoid valve, an atmospheric vacuum breaker, and a discharge manifold with 12 mm (½") dia. compression type copper tube connections on 40 mm (1-½") centres with quantity to suit the number of items to be primed;
- (4) control panel with circuit breaker, 5 A fuse, 24 hour timer, and manual override toggle switch.

2.16 SHOCK ABSORBERS

2.16.1 Type 304 stainless steel piping shock absorbers, each complete with a nesting type bellows and a casing of sufficient displacement volume to dissipate kinetic energy generated in piping system, and each sized to suit connecting water pipe and equipment it is provided for.

- 2.16.2 Manufacturers:
 - 2.16.2.1 Watts Industries (Canada) Inc. "SG" Series.
 - 2.16.2.2 Jay R. Smith 5000 Series "HYDROTROL";
 - 2.16.2.3 Zurn #Z1700 "SHOKTROL";
 - 2.16.2.4 Mifab "HAMMERGUARD" WHB Series;

2.17 WATER HAMMER ARRESTORS

- 2.17.1 Piston type, sealed, all stainless steel construction, pressurized water hammer arrestors suitable for either vertical or horizontal installation, each complete with a pressurized compression chamber, welded nesting-type expansion bellows surrounded by non-toxic mineral oil, and a male treaded nipple connection.
- 2.17.2 Manufacturers:
 - 2.17.2.1 Jay R. Smith 5000 Series;
 - 2.17.2.2 Precision Plumbing Products "SS" Series.
- 2.17.3 Piston type, sealed, pressurized water hammer arrestors suitable for either horizontal or vertical installation, each complete with a hard drawn copper body, "O"-ring piston seals, an air charge, and an inlet opening equal to diameter of pipe in which arrestor is required.
- 2.17.4 Manufacturers:
 - 2.17.4.1 Watts Industries (Canada) Inc. LF05 or LF15M2;
 - 2.17.4.2 Zurn #Z1260;
 - 2.17.4.3 Precision Plumbing Products Inc. SC Series;
 - 2.17.4.4 Mifab MWH Series.

2.18 BACKFLOW PREVENTERS

- 2.18.1 Double Check Valve Assembly
 - 2.18.1.1 Minimum 1205 kPa (175 psi) rated lead-free dual check valve assembly backflow preventer to CAN/CSA B64 (including supplements), complete with tight-closing resilient seated shut-off valves, test cocks and strainer.
 - 2.18.1.2 Manufacturers:
 - (1) Watts Industries Canada;
 - (2) Zurn/Wilkins;
 - (3) Apollo Valves (Conbraco Industries).
- 2.18.2 Reduced Pressure Zone Assembly
 - 2.18.2.1 Lead-free reduced pressure zone assembly backflow preventer in accordance with CAN/CSA B64 (including supplements), each of bronze or epoxy coated cast iron bronze fitted construction depending on size, and complete with inlet strainer, inlet and outlet shut-off valves, an intermediate relief valve, ball valve type test cocks, and a proper air gap fitting.
 - 2.18.2.2 Manufacturers:
 - (1) Watts Industries #LF009QT-S for 12 mm (½") size, #LF909QT-S for 20 mm to 50 mm (¾" to 2") size, and #LF909-NRS-S for 65 mm (2-½") and larger size;
 - (2) Zurn/Wilkins 975XL2 and 375 Series;
 - (3) "Apollo" Valves manufactured by Conbraco Industries Inc. Series 4ALF;
 - (4) Danfoss Flomatic Corp. Series RPZ.

2.19 PIPING EXPANSION COMPENSATORS AND GUIDES

- 2.19.1 Pressurized type, selected to withstand system pressure and to suit calculated movement from -5°C (23°F) to maximum operating temperature plus 25% safety factor, complete

with stainless steel bellows and shroud, copper tube sweat type female ends, anti-torque device, and proper and suitable alignment guides for both sides of each compensator.

2.19.2 Manufacturers:

2.19.2.1 Senior Flexonics Series HB;

2.19.2.2 Hyspan Precision Products Series 8500.

2.20 PIPE ANCHORS

2.20.1 Welded structural black steel anchors of a design, size, and type to securely anchor pipe at point shown. Each anchor is to withstand 150% axial thrust, and is to be designed and detailed by a professional structural engineer registered and licensed in jurisdiction of the work. Submit anchor design and fabrication shop drawings, stamped by design engineer.

2.21 LAVATORY SUPPLY FITTING TEMPERING VALVES

2.21.1 Equal to Powers "HydroGuard" Series 490, model LM490 12 mm (½") dia. or model LM491 20 mm (¾") dia. as required, each CSA B125 certified, forged brass, tamper-proof thermostatic mixing valves, adjustable for water supply between 29°C and 49°C (85°F and 120°F), sized to suit number of lavatories in grouping, and complete with a stop and check valve and a lockable handle.

2.21.2 Each mixing valve is to be complete with a stainless steel flush wall mounting cabinet with vandal-proof hinged door.

2.22 AIR VENTS

2.22.1 Equal to ITT Hoffman Specialty No. 78 cast brass, 1035 kPa (150 psi) rated, 20 mm (¾") straight water main vent valves, each tapped at the top for a 3.2 mm (1/8") safety drain connection.

2.23 DOMESTIC WATER THERMAL EXPANSION TANK

2.23.1 Pre-charged domestic water thermal expansion tank in accordance with Section VIII of the ASME Boiler and Pressure Code, carbon steel outer shell construction and complete with fixed butyl rubber bladder to prevent water from contacting shell interior, top NPT stainless steel system connection, 7.6 mm to 813 mm (0.301" to 32") charging valve connection and prime painted exterior.

2.23.2 Manufacturers:

2.23.2.1 Watts Industries (Canada) Inc. Series DETA;

2.23.2.2 Zurn/Wilkins Model WTTA.

3 EXECUTION

3.1 UNDERGROUND MUNICIPAL SERVICE CONNECTION

3.1.1 Make required arrangements with Municipality for installation of domestic water service piping from Municipal main to property line.

3.1.2 Pay charges levied by Municipality for service connection work.

3.1.3 Municipal charges for underground street service connection work will be paid out of a prime cost allowance. Submit original copies of invoices issued by Municipality for street service connection work.

3.2 PIPING INSTALLATION REQUIREMENTS

3.2.1 Provide required domestic water piping.

3.2.2 Piping, unless otherwise specified, is as follows:

- 3.2.2.1 for underground piping 100 mm (4") dia. and larger outside and/or inside the building – rigid PVC;
- 3.2.2.2 for underground piping less than 100 mm (4") dia. inside building – Type "K" soft copper;
- 3.2.2.3 for pipe 75 mm (3") dia. and larger inside building and above ground – Schedule 10 stainless steel;
- 3.2.2.4 for 12 mm (½") dia. trap seal primer tubing located underground or in concrete or masonry construction – semi-rigid polyethylene;
- 3.2.2.5 for pipe inside building and aboveground in sizes to 100 mm (4") dia., except in vertical shafts and through fire barriers – rigid CPVC;
- 3.2.2.6 for branch hot and cold piping aboveground from mains and risers to fixtures and equipment where fire rated construction is not penetrated – at your option, PEX tubing installed and joined in strict accordance with manufacturer's instructions; when installed in unfinished areas, ensure piping is protected from ultra-violet light exposure.
- 3.2.2.7 for underground piping outside building to fixtures/outlets at grade level – flexible polyethylene, snaked in the trench and in a continuous length wherever possible;
- 3.2.2.8 for pipe inside building and aboveground in sizes to 100 mm (4") dia. – Type "L" hard copper with solder joints.
 - (1) Option: Type "L" hard copper with pressure coupled mechanical joints.
 - (2) Option: Type "L" hard copper with grooved end mechanical joints.
 - (A) Grooved pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing. All couplings will meet Victaulic standards for visual inspection sizes 2" to 8". The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Install in accordance with manufacturer's latest recommendations. A Victaulic factory trained representative shall periodically visit the job site and review the installation for best practices. The installing Contractor shall correct any identified deficiencies. Victaulic product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by Victaulic prior to the completion of the project.
- 3.2.3 Brace and secure underground water service pipe at bends, tees and similar fittings with restraint devices, and provide concrete thrust blocks in accordance with Municipal standards and details. Regardless of what is specified elsewhere in this Specification regarding provisions of concrete, provide thrust block concrete. Paint restraint devices with 2 coats of corrosion resistant black asphalt base coating prior to backfilling.
- 3.2.4 Lay pipes true to line and grade with bells up/grade. Fit sections together so that, when complete, pipe has a smooth and uniform invert. Keep pipe thoroughly clean so jointed compound will adhere. Inspect pipe for defects before being lowered into trench.
- 3.2.5 Slope piping so it can be completely drained.
- 3.2.6 Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe or equipment.

3.3 INSTALLATION OF SHUT-OFF AND CHECK VALVES

- 3.3.1 Refer to Part 3 of Section 20 05 00 – Common Work Results for Mechanical.
-

- 3.3.2 For shut off valves installed on solder joint copper piping up to and including 75 mm (3") diameter, provide ball type valves, and for flanged joints copper or stainless steel piping larger than 75 mm (3") diameter provide butterfly type valves.

3.4 *INSTALLATION OF DRAIN VALVES*

- 3.4.1 Provide a drain valve at the bottom of domestic water piping risers, at other piping low points, and wherever else shown.
- 3.4.2 Locate drain valves so they are easily accessible.

3.5 *INSTALLATION OF DOMESTIC HOT WATER PIPING BALANCING VALVES*

- 3.5.1 Provide balancing valves in domestic hot water recirculation piping where shown or required.
 - 3.5.1.1 for pipe 25 mm (3/4") dia. and less ground – equal to Victaulic Series 76X
 - 3.5.1.2 for pipe greater than 25 mm (3/4") dia. – equal to Victaulic TA Series 78BL
- 3.5.2 Locate each valve so it is easily accessible.

3.6 *INSTALLATION OF PARTITION STOPS*

- 3.6.1 Provide partition stops in domestic water piping to each group of suite washroom plumbing fixtures. Locate partition stops in piping near floor level in inconspicuous but accessible locations. Confirm exact locations prior to roughing-in.

3.7 *INSTALLATION OF PRESSURE REDUCING VALVES*

- 3.7.1 Provide domestic water pressure reducing valves. Install so each valve is readily accessible. Whenever possible, provide pressure reducing valves factory pre-set to required pressures.
- 3.7.2 Check and test operation, and adjust as required.

3.8 *INSTALLATION OF DOMESTIC HOT WATER THERMOSTATIC MIXING VALVES*

- 3.8.1 Provide a domestic hot water thermostatic mixing valve assembly and wall mount.
- 3.8.2 Adjust each valve to design requirements and check and test operation. Set maximum temperature limit stops.
- 3.8.3 Identify each valve and its water temperature delivery setting with an engraved nameplate.

3.9 *INSTALLATION OF WATER METER*

- 3.9.1 Provide domestic water service meter. Secure meter in place on a concrete housekeeping pad and connect with piping, including required valve by-pass.
- 3.9.2 Installation of water meter must comply with local municipal requirement.

3.10 *INSTALLATION OF HOSE BIBBS*

- 3.10.1 Provide hose bibbs.
- 3.10.2 Unless otherwise shown, specified, or required, mount hose bibbs approximately 1 m (3') above floor. Confirm exact locations prior to roughing-in.

3.11 *INSTALLATION OF EXTERIOR NON-FREEZE WALL HYDRANTS*

- 3.11.1 Provide non-freeze wall hydrants.
 - 3.11.2 Install hydrants level and plumb such that hose outlets are approximately 600 mm (2') above grade level. Confirm exact locations prior to roughing-in.
 - 3.11.3 Provide a shut-off valve inside building to each exterior non-freeze wall hydrant.
-

3.12 INSTALLATION OF EXTERIOR NON-FREEZE GROUND HYDRANTS

- 3.12.1 Provide non-freeze ground hydrants. Confirm exact locations prior to roughing-in.
- 3.12.2 Ensure length of piping to outlet box suits depth of underground piping, and underground piping elbow and valve housing is set in an envelope of clean sharp, 100% Proctor density compacted sand. Provide a length of small bore copper tubing from valve drain port into sand envelope.
- 3.12.3 Provide a shut-off valve inside building to each ground hydrant.

3.13 INSTALLATION OF NON-FREEZE ROOF HYDRANT

- 3.13.1 Provide non-freeze roof hydrants. Confirm exact locations prior to roughing-in.
- 3.13.2 Coordinate installation with trades providing roof opening and roofing work to ensure a water-tight roof penetration.
- 3.13.3 Provide 3.2 mm (1/8") diameter drain piping from inlet connection assembly inside building to a funnel floor drain or other suitable indirect connection location.

3.14 INSTALLATION OF TRAP SEAL PRIMERS

- 3.14.1 Provide required accessible trap seal primers to automatically maintain a water seal in floor drain traps, whether shown on drawings or not.
- 3.14.2 Water closet flush valves may be used for priming washroom floor drain traps if flush tube is properly tapped and primer tubing exposed in washroom is chrome plated.
- 3.14.3 Provide trap primer valves to prime single or multiple (1 to 6) traps. Install trap primer valves in domestic cold water piping to frequently used plumbing fixtures. Where from 2 to 6 traps are to be primed from same primer valve, provide appropriate supply and distribution tube assemblies. Ensure primer valves are accessible.
- 3.14.4 Provide 115 volt, electronic, surface wall mounting trap primer assemblies for multiple (4 to 30) traps. Include for a 115 volt 15 ampere panel breaker and wiring in conduit from closest panelboards to primer assembly, all to wiring standards of Electrical Division. Adjust primer water flow and timing to suit number of traps served.
- 3.14.5 Ensure trap primer piping is secured to floor drain primer tappings and not terminated through the tapping in the throat of the drain.

3.15 INSTALLATION OF SHOCK ABSORBERS

- 3.15.1 Provide accessible shock absorbers in make-up water piping to equipment.
- 3.15.2 Ensure size of each shock absorber is properly selected to suit size of water pipe and equipment pipe is connected to.
- 3.15.3 Install down stream of backflow preventor.

3.16 INSTALLATION OF WATER HAMMER ARRESTORS

- 3.16.1 Provide accessible water hammer arrestors in domestic water piping in locations as follows:
 - 3.16.1.1 in headers at groups of plumbing fixtures;
 - 3.16.1.2 at top of risers;
 - 3.16.1.3 at ends of long horizontal runs of piping;
 - 3.16.1.4 in piping connecting solenoid valves or equipment with integral solenoid valves;
 - 3.16.1.5 wherever else shown or required by Code.
 - 3.16.2 Install each unit in a piping tee either horizontally or vertically in the path of potential water shock in accordance with manufacturer's instructions and details.
-

3.17 INSTALLATION OF BACKFLOW PREVENTERS

- 3.17.1 Provide a reduced pressure zone assembly backflow preventer on incoming DCW service and in each direct domestic water connection to equipment other than plumbing fixtures and fittings.
- 3.17.2 Provide a double check valve assembly backflow preventer on incoming DCW service. Provide a reduced pressure zone assembly backflow preventer in each direct domestic water connection to equipment other than plumbing fixtures and fittings.
- 3.17.3 Locate each backflow preventer on floor or wall between 765 mm and maximum 1.5 m (30" and 60") above floor such that it is easily accessible for maintenance and testing.
- 3.17.4 Equip each reduced pressure zone backflow preventer with an air gap fitting and pipe the reduced pressure zone water outlet to drain.
- 3.17.5 Test operation of each backflow preventer in accordance with requirements of CAN/CSA B64 by personnel certified for such testing by governing authorities, and submit signed test results and a properly and clearly identified and marked inspection and test record card for each backflow preventer.

3.18 INSTALLATION OF EXPANSION COMPENSATORS, GUIDES, AND ANCHORS

- 3.18.1 Provide expansion compensators in domestic water piping.
- 3.18.2 Ensure pipe ends are properly aligned. Provide alignment guides on each side of expansion compensators, properly secured to building structure.
- 3.18.3 Provide anchors to secure domestic water piping to structure. Locate anchors generally where shown but with exact locations to suit piping as installed and requirements of reviewed anchor shop drawings.
- 3.18.4 When installation of anchors is complete, arrange, and pay for anchor design engineer to visit site to review anchor installation. Submit a letter from design engineer confirming each anchor is properly installed.

3.19 INSTALLATION OF LAVATORY SUPPLY FITTING TEMPERING VALVES

- 3.19.1 Provide thermostatic water tempering valves for hot water supply to public washroom lavatory supply fittings. Conceal valves and piping.
- 3.19.2 Provide a flush wall mount panel for each valve. Confirm exact location prior to roughing-in.
- 3.19.3 Install in accordance with manufacturer's instructions and set mixing valves to deliver 32°C (90°F) tempered water.

3.20 INSTALLATION OF AIR VENTS

- 3.20.1 Provide accessible air vents in domestic water piping to prevent air binding.
- 3.20.2 Extend copper indirect drain piping from top drain connection of each vent to nearest suitable drain.
- 3.20.3 Locate exact vent locations on as-built record drawings.

3.21 INSTALLATION OF DOMESTIC WATER THERMAL EXPANSION TANKS

- 3.21.1 Provide domestic water thermal expansion tanks.
 - 3.21.2 Unless otherwise specified, mount at least 450 mm (18") from cold water inlet to domestic water heater.
 - 3.21.3 Adjust pre-charge to match incoming water pressure after installation.
 - 3.21.4 Install in accordance with manufacturer's instructions and as per local governing Codes and Regulations.
-

3.22 FLUSHING AND DISINFECTING PIPING

- 3.22.1 Flush and disinfect all new and/or reworked domestic water piping after leakage testing is complete.
- 3.22.2 Isolate new piping from existing piping prior to flushing and disinfecting procedures.
- 3.22.3 Flush piping until all foreign materials have been removed and flushed water is clear. Provide connections and pumps as required. Open and close valves, faucets, hose outlets, and service connections to ensure thorough flushing.
- 3.22.4 When flushing is complete, disinfect the piping with a solution of chlorine in accordance with AWWA C601.
- 3.22.5 When disinfecting is complete, submit water samples to a certified laboratory for purity testing and, when testing indicates pure water in accordance with governing standards, submit a copy of test results and fill the systems.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Domestic hot water recirculation pumps.
- 1.1.2 Controls.

1.2 SUBMITTALS

- 1.2.1 Submit shop drawings/product data sheets for all equipment and associated hardware specified in this Section.
- 1.2.2 Include pump motor product data sheets and pump performance curves with shop drawing/product data sheet submission.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Submit manufacturer/supplier installation certification letters as specified in Part 3 of this Section.
- 1.3.2 Submit a copy of a letter from the domestic cold water booster pump set supplier certifying proper installation, and a copy of pump supplier's start-up report, all as specified in Part 3 of this Section.
- 1.3.3 Submit, prior to Substantial Performance of the Work, start-up or test data specified in Part 3 of this Section.

2 PRODUCTS

2.1 DOMESTIC HOT WATER RECIRCULATING PUMPS

- 2.1.1 All bronze construction centrifugal pumps in accordance with drawing schedule and complete with:
 - 2.1.1.1 lead free cast bronze casing with flanged pipe connections;
 - 2.1.1.2 alloy steel shaft with integral thrust collar, copper shaft sleeve, and oil lubricated bronze sleeve bearings;
 - 2.1.1.3 balanced lead free cast bronze impeller;
 - 2.1.1.4 motor conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical, connected to motor by means of a 4-spring coupling with guard;
 - 2.1.1.5 mechanical seal.
 - 2.1.2 Manufactures:
 - 2.1.2.1 S.A. Armstrong Ltd.;
 - 2.1.2.2 ITT Bell & Gossett;
 - 2.1.2.3 Grundfos Canada Inc.;
 - 2.1.2.4 Patterson Pump Company.
 - 2.1.3 Domestic Hot Water Recirculating Pumps Automatic Controls
 - 2.1.3.1 Equal to ITT Bell & Gossett Model TC-1 115 volt, programmable, Automatic Timer Kit to control circulating pump on and off at pre-set minimum 15 minute intervals, and equipped with ON (continuous run), OFF (at all times), and TIMER (run at programmed times) modes.
 - 2.1.3.2 Equal to ITT Bell & Gossett AQS Series 115 volt Aquastat to automatically control pump on and off in response to domestic water temperature and equipped with a stainless steel pipe clip, bimetal sensing element, and insulated #18 AWG 450 mm (18") wire leads.
-

3 EXECUTION

3.1 *INSTALLATION OF DOMESTIC HOT WATER RECIRCULATING PUMPS*

- 3.1.1 Provide horizontal in-line domestic hot water circulating pumps.
- 3.1.2 Install pumps in place in vertical piping approximately 1.2 m (4') above floor in accordance with pump manufacturer's instructions.
- 3.1.3 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.1.4 Include for 2 hours of on-site training for 2 groups of 6 people. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.2 *INSTALLATION OF DOMESTIC HOT WATER RECIRCULATING PUMPS CONTROLS*

- 3.2.1 Provide a programmable timer and an aquastat to automatically control pump on and off in response to pre-set times and domestic water temperatures. Install in accordance with manufacturer's instructions. Programme both devices in accordance with Consultant's instructions.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit a copy of plumbing inspection certificate prior to application for Substantial Performance of the Work.
- 1.2.2 Submit letters from product manufacturers/suppliers to certify correct installation of products as specified in Part 3 of this section.
- 1.2.3 Record Drawings: Indicate inverts of new below grade sanitary and storm piping on as-built drawings.

2 PRODUCTS

2.1 PIPE, FITTINGS, AND JOINTS

- 2.1.1 PVC Sewer
 - 2.1.1.1 DR35 rigid, green PVC hub and spigot pattern sewer pipe and fittings to CAN/CSA B182.2, with gasket joints assembled with pipe lubricant.
 - 2.1.1.2 DR35 rigid, PVC sewer pipe and fittings, with solvent weld joints, all certified to CSA B182.1 and colour-coded as per local governing codes, regulations and standards.
 - 2.1.2 PVC - DWV
 - 2.1.2.1 For Low Buildings: Equal to IPEX System 15 drain, waste and vent pipe and fittings to CAN/CSA B181.2, complete with a flame spread rating not more than 25 when tested to CAN/ULC S102.2, with solvent weld joints or MJ Grey mechanical joint couplings, and, for fire barrier penetration, approved firestop conforming to CAN/ULC S115.
 - 2.1.2.2 For High Buildings and Plenums: Equal to IPEX System XFR drain, waste and vent pipe and fittings to CAN/CSA B181.2, complete with a flame spread rating not more than 25 and a smoke developed classification not more than 50 when tested to CAN/ULC S102.2, with solvent weld joints or MJ Grey mechanical joint couplings, and, for fire barrier penetration, approved firestop conforming to CAN/ULC S115.
 - 2.1.3 Copper - Solder Joint
 - 2.1.3.1 Type DWV hard temper to ASTM B306, with forged copper solder type drainage fittings and 50% lead - 50% tin solder joints.
 - 2.1.4 Cast Iron
 - 2.1.4.1 Class 4000 cast iron pipe, fittings, and mechanical coupling joints to CAN/CSA B70.
 - 2.1.5 Copper-Victaulic Coupling Joint
 - 2.1.5.1 Type DWV hard temper to ASTM B306, with factory or site rolled grooved ends (with grooving rolls designed for copper) and Victaulic "Copper Connection" wrought copper or cast bronze fittings and Style 606 gasket type couplings.
 - 2.1.6 Galvanized Steel - Victaulic Coupling Joint
 - 2.1.6.1 Schedule 40 mild steel, galvanized, ASTM A53, factory or site rolled grooved, complete with Victaulic galvanized ductile iron grooved end fittings and, unless otherwise specified, Victaulic Style 77 hot dip galvanized mechanical joint couplings with Grade M gaskets.
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- 2.1.7 PVC Weeper Piping
 - 2.1.7.1 150 mm (6") dia. corrugated perforated PVC pipe with an integral geodesic sock, supplied in coils.

2.2 SHUT-OFF AND CHECK VALVES

- 2.2.1 Shut-off Valves
 - 2.2.1.1 Class 600, 4140 kPa (600 psi) WOG rated full port ball valves, each complete with a forged brass body, blowout-proof stem, chrome plated solid brass ball, solder or screwed ends as required, and removable lever handle.
 - 2.2.1.2 Manufacturers:
 - (1) Toyo Valve Co. Fig. 5049A or Fig. 5044A;
 - (2) Milwaukee Valve Co. #BA-155 or #BA -125;
 - (3) Kitz Corporation Code 58 or Code 59;
 - (4) Victaulic Co. of Canada Ltd. Series 722;
 - (5) Apollo Valves # 77-100 or # 77-200;
 - (6) Watts Industries (Canada) Inc. #FBVS-3C.
- 2.2.2 Check Valves
 - 2.2.2.1 Class 125, bronze, 1725 kPa (250 psi) WOG rated vertical lift check valve with solder or screwed ends as required, and, for horizontal piping, Class 125, bronze 1380 kPa (200 psi) WOG rated swing check valves with solder or screwed ends.
 - 2.2.2.2 Manufacturers:
 - (1) Toyo Valve Co. Fig. 231 or Fig. 236 or Fig. 237;
 - (2) Milwaukee Valve Co. #1510 or #510;
 - (3) Kitz Corporation Code 36 or Code 22 or Code 23.

2.3 VENT STACK COVERS

- 2.3.1 Equal to Lexcor Model "Flash-Tite" seamless, spun aluminum, insulated vent stack covers with caps and a factory applied asphalt primer coating on top and bottom of flange.
- 2.3.2 Each vent stack cover is to be complete with a vandal-proof cap.

2.4 CLEANOUTS

- 2.4.1 Horizontal Piping
 - 2.4.1.1 TY pipe fitting with an extra heavy brass plug screwed into the fitting.
 - 2.4.2 Vertical Piping
 - 2.4.2.1 Bronze or copper cleanout tees in copper piping, each complete with a bronze ferrule, and, for cast iron piping, "BARRETT" type cast iron cleanout tees, each gas and water-tight and complete with a bolted cover.
 - 2.4.3 Urinal(s)
 - 2.4.3.1 Wall access cleanout assemblies, each complete with a tapered plug, threaded brass insert, urethane rubber seal, and polished stainless steel access cover with vandal-proof stainless steel securing screw.
 - 2.4.3.2 Manufacturers:
 - (1) Watts Industries (Canada) Ltd. #CO-590-RD.
 - (2) Jay R. Smith #SQ4-1819;
 - (3) Zurn #ZSS-1666-1;
-

(4) Mifab #C1440-RD;

2.5 FLOOR CLEANOUT TERMINATIONS

- 2.5.1 Factory finished cast iron terminations, each adjustable and complete with a cast iron body with neoprene sleeve, solid, gasketed, polished nickel-bronze scoriated top access cover to suit floor finish, a seal plug, and captive, vandal-proof, stainless steel securing hardware.
- 2.5.2 Manufacturers:
 - 2.5.2.1 Watts Industries (Canada) Ltd. # CO-200-R-1.
 - 2.5.2.2 Jay R. Smith #4020-F-C Series;
 - 2.5.2.3 Zurn # ZN-1602-SP Series;
 - 2.5.2.4 Mifab # C1100-XR-1 or #C1000-R-3;
- 2.5.3 Cleanout terminations in areas with a tile or sheet vinyl floor finish are to be as above but with a square top in lieu of a round top.

2.6 FLOOR DRAINS, FUNNEL FLOOR DRAINS, AND HUB DRAINS

- 2.6.1 Unless otherwise specified or indicated, floor drains are to be vandal-proof drains in accordance with drawing symbol list, each complete with a cast iron body and a trap seal primer connection. Cast iron components are to be factory finished with latex based paint coating.
- 2.6.2 Floor drains in areas with a tile or sheet vinyl floor finish are to be as above but with a square grate in lieu of a round grate.
- 2.6.3 Manufacturers:
 - 2.6.3.1 Watts Industries (Canada) Ltd.;
 - 2.6.3.2 Jay R. Smith Manufacturing Co.;
 - 2.6.3.3 Zurn Industries Ltd.;
 - 2.6.3.4 Mifab Inc.

2.7 ROOF DRAINS

- 2.7.1 Unless otherwise specified or indicated, roof drains are to be cast iron body drains with aluminium domes, in accordance with the drawing symbol list. Cast iron components are to be factory finished with a latex based paint coating.
- 2.7.2 Manufacturers:
 - 2.7.2.1 Watts Industries (Canada) Ltd.;
 - 2.7.2.2 Jay R. Smith Manufacturing Co.;
 - 2.7.2.3 Zurn Industries Ltd.;
 - 2.7.2.4 Mifab Inc.

2.8 INTERIOR CATCH BASIN FRAMES AND COVERS

- 2.8.1 Heavy-duty, 508 mm (13") square, baked epoxy coated cast iron, non-removable, hinged slotted grate with coated steel frame with concrete anchors.
- 2.8.2 Manufacturers:
 - 2.8.2.1 Watts Industries (Canada) Ltd. #FD-410;
 - 2.8.2.2 Jay R. Smith #8915FC;
 - 2.8.2.3 Zurn #Z-799-1;
 - 2.8.2.4 Mifab #F1570.

2.9 BACKWATER VALVES

- 2.9.1 Heat bonded powder epoxy coated cast iron in-line type, each complete with a bolted and gasketed cover, bronze flapper, stainless steel extension, and stainless steel hardware.
 - 2.9.2 Manufacturers:
-

- 2.9.2.1 Watts Industries (Canada) Inc. BV-230-R Series;
- 2.9.2.2 Jay R. Smith #7022-CAN.
- 2.9.2.3 Zurn #Z-1095-15-MJ;

2.10 EXTERIOR CATCH BASINS

- 2.10.1 Pre-cast reinforced concrete catch basins manufactured to ASTM C478 and Municipal standards, each sized and arranged to suit drainage pipe size and arrangement, and complete with:
 - 2.10.1.1 cast iron frame and cover to Municipal standards;
 - 2.10.1.2 required masonry work to raise top of catch basins flush with finished grade or pavement surfaces.
- 2.10.2 Masonry work is to consist of cement mortar and clay or shale bricks to ASTM C32 Grade M5, or Oaks Precast Industries "MODULOC" pre-cast interlocking concrete members and accessories.

2.11 EXTERIOR MANHOLES

- 2.11.1 Pre-cast reinforced concrete manholes manufactured to ASTM C478 and Municipal standards, each sized and arranged to suit drainage pipe size and arrangement, and complete with:
 - 2.11.1.1 poured-in-place or pre-cast concrete base;
 - 2.11.1.2 cast-in-place "Safety" type aluminum steps on 300 mm (12") centres, each step coated with 2 coats of static asphalt paint;
 - 2.11.1.3 unperforated cast iron cover with lifting holes and a matching frame;
 - 2.11.1.4 as required by manhole depth and safety regulations, cast-in-place hinged aluminum safety grating with SG 1 1 R-T6 aluminum alloy bearing bars, aluminum grate to CAN/CSA S157, and self-locking type stainless steel hinges and fasteners with galvanized steel safety chain and snap hook;
 - 2.11.1.5 required masonry work to raise top of manholes flush with finished grade.
- 2.11.2 Masonry work is to consist of cement mortar and clay or shale bricks to ASTM C32 grade M5, or Oaks Precast Industries "MODULOC" pre-cast interlocking concrete members and accessories.

2.12 GREASE INTERCEPTORS

- 2.12.1 Grease intercepting and recovery unit of #11 gauge type 304 stainless steel construction with sensor controlled grease draw-off solenoid valve, automatic shut-down with audible/visual alarm if maximum grease capacity is exceeded, integral heating element with thermostat, gasketed stainless steel cover, stainless steel solids interceptor, and remote surface wall mounting indicator panel with status indicating lights, audible alarm, 115/24 volt control transformer and NEMA 2 enclosure.
- 2.12.2 Manufacturers:
 - 2.12.2.1 Watts Industries (Canada) Inc. WD-E Series;
 - 2.12.2.2 Jay R. Smith #8000-ELECT series or #8400-ELECT series.
 - 2.12.2.3 Zurn #Z1172-UN series;

2.13 OIL INTERCEPTORS

- 2.13.1 Epoxy coated steel construction automatic oil interceptor with removable baffles, deep seal trap with cleanout, sediment bucket, aluminum frame and cover, and remote wall mounting indicating panel with status indicating lights, audible alarm, 115/24 volt control transformer, and NEMA 2 surface wall mounting enclosure.
 - 2.13.2 Manufacturers:
 - 2.13.2.1 Watts Industries (Canada) Inc. OI-SS / HI 7873 Series;
 - 2.13.2.2 Jay R. Smith 8500-SC-ELECT-CAN Series.
-

2.13.2.3 Zurn #Z1198 series;

3 EXECUTION

3.1 UNDERGROUND MUNICIPAL SERVICE CONNECTION

- 3.1.1 Make required arrangements with Municipality for installation of drain service piping mains from Municipal main to property line.
- 3.1.2 Pay charges levied by Municipality for service connection work.
- 3.1.3 Municipal charges for underground street service connection work will be paid out of a prime cost allowance. Submit original copies of invoices issued by Municipality for street service connection work.

3.2 DRAIN AND VENT PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide required drainage and vent piping. Pipe, unless otherwise specified, as follows:
 - 3.2.1.1 for underground pipe inside building and to points 1.5 m (5') outside building lines – rigid PVC sewer pipe, minimum 75 mm (3") dia.;
 - 3.2.1.2 for pipe inside building and aboveground in sizes less than or equal to 65 mm (2-½") dia. – type DWV copper;
 - 3.2.1.3 for pipe inside building and aboveground in sizes greater than or equal to 75 mm (3") dia. – Class 4000 cast iron;
 - 3.2.1.4 for pipe inside building and aboveground in lieu of type DWV copper and cast iron, at your option and where permitted by governing Codes and Regulations – rigid PVC DWV;
 - 3.2.1.5 for drainage pump discharge pipe connections from pump to and including shut-off and check valve connections – Type "DWV" copper with Victaulic "Copper Connection" fittings and couplings, or Schedule 40 galvanized steel with Victaulic fittings and couplings.
- 3.2.2 Unless otherwise specified, slope horizontal drainage piping aboveground in sizes to and including 75 mm (3") dia. 25 mm (1") in 1.2 m (4'), and pipe 100 mm (4") dia. and larger 25 mm (1") in 2.4 m (8').
- 3.2.3 Install and slope underground drainage piping to inverts or slopes indicated on drawings to facilitate straight and true gradients between points shown. Verify available slopes before installing pipes.
- 3.2.4 Unless otherwise specified, slope horizontal branches of vent piping down to fixture or pipe to which they connect with a minimum pitch of 25 mm (1") in 1.2 m (4').
- 3.2.5 Extend vent stacks up through roof generally where shown but with exact locations to suit site conditions and in any case a minimum of 3 m (10') from fresh air intakes. Terminate vent stacks a minimum of 330 mm (13") above roof (including roof parapets) in vent stack covers. Where not shown on drawings, route vent piping from source to building exterior as required in order to satisfy local governing codes and authority. Coordinate vent routing with other building services and ensure there is no architectural impact.
- 3.2.6 Provide cast brass dielectric unions at connections between copper pipe and ferrous pipe or equipment.

3.3 INSTALLATION OF SHUT-OFF AND CHECK VALVES

- 3.3.1 Provide a shut-off valve and a check valve in discharge piping of each drainage pump.
 - 3.3.2 Locate valves so they are easily accessible without the use of ladders or other such devices.
-

3.4 SUPPLY OF VENT STACK COVERS

- 3.4.1 Supply a properly sized vent stack cover for each vent stack penetrating roof.
- 3.4.2 Hand vent stack covers to roofing trade at site for installation and flashing into roof construction as part of roofing work. Coordinate installation to ensure proper locations. Provide waterproofing caps over vent stacks.

3.5 INSTALLATION OF CLEANOUTS

- 3.5.1 Provide cleanouts in drainage piping in locations as follows:
 - 3.5.1.1 in building drain or drains as close as possible to inner face of outside wall, and, if a building trap is installed, locate cleanout on downstream side of building trap;
 - 3.5.1.2 at or as close as practicable to the foot of each drainage stack;
 - 3.5.1.3 at maximum 15 m (50') intervals in horizontal pipe 100 mm (4") dia. and smaller;
 - 3.5.1.4 at maximum 30 m (100') intervals in horizontal pipe larger than 100 mm (4") dia.;
 - 3.5.1.5 in the wall at each new urinal or bank of urinals in a washroom;
 - 3.5.1.6 wherever else shown on drawings.
- 3.5.2 Cleanouts are to be same diameter as pipe in piping to 100 mm (4") dia., and not less than 100 mm (4") dia. in piping larger than 100 mm (4") dia.
- 3.5.3 Where cleanouts in vertical piping are concealed behind walls or partitions, install cleanouts near floor and so cover is within 25 mm (1") of the finished face of the wall or partition.

3.6 INSTALLATION OF FLOOR CLEANOUT TERMINATIONS

- 3.6.1 Where cleanouts occur in horizontal inaccessible underground piping, extend cleanout TY fitting up to floor, and provide a cleanout termination set flush with finished floor.
- 3.6.2 In waterproof floors, ensure each cleanout termination is equipped with a flashing clamp device. Cleanout terminations are to suit floor finish.
- 3.6.3 Where cleanout terminations occur in finished areas, confirm locations prior to rough-in and arrange piping to suit.
- 3.6.4 Ensure cleanout termination covers in tiled floor are square in lieu of round.

3.7 INSTALLATION OF FLOOR DRAINS, FUNNEL FLOOR DRAINS AND HUB DRAINS

- 3.7.1 Provide floor drains, funnel floor drains and hub drains.
 - 3.7.2 Coordinate location of floor drains, funnel floor drains and hub drains with equipment provided by Mechanical Division and Owner's supplied equipment. Install in accordance with manufacturer's instructions.
 - 3.7.3 Equip each drain with a trap.
 - 3.7.4 In equipment rooms and similar areas, exactly locate floor drains to suit location of mechanical equipment and equipment indirect drainage piping. In washrooms, exactly locate floor drains to avoid interference with toilet partitions.
 - 3.7.5 Confirm exact location of drains prior to roughing in. Where floor drains occur in washrooms coordinate locations with toilet partition installations.
 - 3.7.6 Temporarily plug and cover floor drains during construction procedures. Remove plugs and covers during final clean-up work and when requested, demonstrate free and clear operation of each drain. Replace any damaged grates, and refinish any areas of the drain where cast iron finish has been damaged or removed, including rusted areas.
-

3.8 *INSTALLATION OF ROOF DRAINS*

- 3.8.1 Supply roof drains and place roof drain bodies in position for flashing into roof construction as part of roofing work. Connect with piping and provide accessories.
- 3.8.2 Protect roof drains from damage and entrance of debris until roofing work is complete, and refinish any areas where cast iron factory finish has been damaged or removed, including rusted areas.

3.9 *INSTALLATION OF DRAINAGE TRENCH FRAMES AND GRATING*

- 3.9.1 Supply frame and grating sections for drainage trench. Provide piping connections, traps, etc., as required.
- 3.9.2 Hand frames to concrete trade forming and pouring trenches. Ensure frames are properly and accurately installed.
- 3.9.3 Be present during concrete pour to ensure frames are not dislodged or damaged and remain straight and true. Immediately report any problems.
- 3.9.4 Install grates and secure in place. Temporarily cover grates during construction procedures. Clean trenches when work is complete.

3.10 *INSTALLATION OF TRENCH DRAINS*

- 3.10.1 Provide pre-sloped sections of drainage channel and install so top frames are level and plumb in relation to floor finishes. Provide accessories, traps, etc., as required.
- 3.10.2 Be present during concrete pour to ensure trench drainage is not dislodged or damaged and remains straight and true. Immediately report any problems.
- 3.10.3 Install grating and secure in place.
- 3.10.4 Temporarily cover trench drainage openings during construction procedures. Clean trenches when work is complete.

3.11 *INSTALLATION OF INTERIOR CATCH BASIN FRAMES AND COVERS*

- 3.11.1 Supply frames and hinged grates for interior catch basins and provide sump inlet and outlet piping and accessories.
- 3.11.2 Hand frames to concrete trade pouring concrete sump, and coordinate installation of sump piping with the formwork installation.
- 3.11.3 Install grates and secure in place. Clean sumps when work is complete.

3.12 *INSTALLATION OF BACKWATER VALVES*

- 3.12.1 Provide backwater valves in drainage piping and connect with piping.
- 3.12.2 Set backwater valve assembly such that cover is flush with finished floor. Provide an extension piece if required due to depth of piping.

3.13 *INSTALLATION OF EXTERIOR MANHOLES*

- 3.13.1 Provide pre-cast concrete manholes. Properly bed each unit and set to required invert.
 - 3.13.2 Provide a reinforced pre-cast concrete base slab and bottom section for each manhole, or provide a poured-in-place concrete base. Ensure each manhole is sized to suit pipe size and arrangement. Conform to Municipal installation standards.
 - 3.13.3 Provide masonry work required to raise top of each assembly flush with finished grade level.
 - 3.13.4 When work is substantially complete, clean out each manhole.
-

3.14 *INSTALLATION OF EXTERIOR CATCH BASINS*

- 3.14.1 Provide pre-cast concrete catch basins. Properly bed each unit and set to required invert.
- 3.14.2 Ensure each catch basin is sized to suit pipe size and arrangement. Conform to Municipal installation standards.
- 3.14.3 Provide masonry work required to raise top of each assembly flush with finished grade level.
- 3.14.4 When work is substantially complete, clean out each catch basin.

3.15 *INSTALLATION OF DRAINAGE INTERCEPTOR*

- 3.15.1 Provide an interceptor in drainage piping.
- 3.15.2 Ensure unit is easily accessible for maintenance. Confirm exact location prior to roughing-in.
- 3.15.3 Wall mount control panel and provide required 24 volt control wiring in conduit from control panel to interceptor.
- 3.15.4 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.15.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical. Submit a copy of the letter prior to Substantial Performance of the Work.
- 3.15.6 Include for 2 hours of on-site training for 2 groups of 6 people. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

1 GENERAL

1.1 RELATED REQUIREMENTS

- 1.1.1 Section 03 30 00 – Cast-in-Place Concrete.
- 1.1.2 Section 22 13 00 – Facility Sanitary Sewerage.

1.2 SUBMITTALS

- 1.2.1 Shop Drawings: Submit shop drawings in accordance with Section 01 33 00.
- 1.2.2 Operation and Maintenance Data: Submit printed operation instructions and maintenance data in accordance with Section 01 77 00.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Northstar Industries (basis of design).
- 2.1.2 ACO Drain Systems.

2.2 MATERIALS

- 2.2.1 Trench drains to be 'MEA ENZ2000' with 200 mm inside width polymer concrete system with integral galvanized finish cast iron edge rails, to the following specifications:
 - 2.2.1.1 Channel body: polymer concrete in 1000 mm (39 3/8") lengths.
 - 2.2.1.2 Grating: MEA F-load slotted HDG ductile iron grating with Profix stainless steel locking mechanism.
 - 2.2.1.3 Channel and grate suitable for application and capable of withstanding all vehicle loads anticipated.
 - 2.2.1.4 Catch Basin: FTC 223 Galvanized steel with rust retardant coating and H2O rated hot dip galvanized steel grating.
 - 2.2.1.5 End caps to be polymer concrete with cast iron edge rail.
 - 2.2.1.6 Supplier contact: Northstar Industries, tel: 1-877-385-5130 / 1-905-571-0613.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install trench drain in accordance with manufacturer's instructions. Connect to sanitary lines as detailed in Section 22 13 00. Coordinate installation with Division 03.
- 3.1.2 Trench drains to be installed as per manufacturer's instructions with rebar support, installation devices and sealant.
- 3.1.3 Sealant should be installed on the edge of trenches before the next channel piece is attached to the body.
- 3.1.4 Provide each trench drain installation with a deep seal "P" trap unless otherwise shown, complete with trap primer connection tapping to conform to code requirements.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Heat Pump Water Heaters.
- 1.1.2 Equipment functions by absorbing ambient heat from the surrounding air to heat domestic water using a compressor and refrigerant:
 - 1.1.2.1 Self-contained heat pump unit is integrated into the top of the tank.
 - 1.1.2.2 Multiple operating modes to maximize efficiency and performance.

1.2 SUBMITTALS

- 1.2.1 Submit shop drawings/product data sheets for all equipment and associated hardware specified in this Section.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Submit with delivery of heater(s) a copy of the factory inspection and test report for each heater, and include a copy of each report with O&M Manual project closeout data.
- 1.3.2 Submit manufacturer/supplier installation certification letters as specified in Part 3 of this Section.
- 1.3.3 Submit, prior to Substantial Performance of the Work, start-up or test data specified in Part 3 of this Section.

1.4 WARRANTY

- 1.4.1 10 year tank and parts warranty.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 A.O. Smith Water Products Co., ProLine XE series.
- 2.1.2 Substitutions: equivalent products from the following manufacturers:
 - 2.1.2.1 John Wood (GWS Water Heating Co.).
 - 2.1.2.2 Rheem Canada Ltd.
 - 2.1.2.3 Bradford White Canada Inc.

2.2 HEAT PUMP

- 2.2.1 Self-contained heat pump unit integrated into the top of the tank.
- 2.2.2 R134a refrigerant.
- 2.2.3 The compressor transfers heat to the water while dehumidifying and cooling the ambient indoor air.

2.3 ELECTRIC ELEMENTS

- 2.3.1 Backup for Heat Pump.

2.4 OPERATING MODES

- 2.4.1 Efficiency mode: Utilizes the heat pump for all water heating.
- 2.4.2 Electric mode: Standard electric water heater operation.
- 2.4.3 Hybrid mode:
 - 2.4.3.1 Hybrid mode automatically adjusts between compressor and element, depending upon heat requirements.

- 2.4.3.2 Automatically reverts to heating element if ambient air or water temperatures are outside optimal operating range for heat pump.
- 2.4.3.3 Utilizes the heat pump or heating element, depending on demand.

2.5 FEATURES

- 2.5.1 Anode Rod
 - 2.5.1.1 Anode rods with stainless steel core to extends the life of the anode rod and extend tank protection.
 - 2.5.1.2 For 66 gallon and 80 gallon models, provide dual anodes.
- 2.5.2 Dry Fire Protection
 - 2.5.2.1 Control system checks to ensure the tank is full of water during start up to prevent dry firing the heating elements.
- 2.5.3 Electronic User Interface
 - 2.5.3.1 User-friendly electronic interface allows easy control of temperature setting, operating mode, and communicates diagnostics.
 - 2.5.3.2 Easy to read temperature display shows temperature in °C or °F.
 - 2.5.3.3 Diagnostics convey error messages for service purposes and the last four error messages are saved in the control system memory.
- 2.5.4 Washable air filter is easily removed for routine cleaning.
- 2.5.5 Non-CFC foam insulation.
- 2.5.6 Enhanced-flow tamper-resistant brass drain valve.
- 2.5.7 51 dBA decibel level during operation.
- 2.5.8 CSA certified and ASME rated temperature and pressure relief valve.

2.6 OPTIONAL DUCTING KIT

- 2.6.1 Permits installation in confined spaces.
- 2.6.2 Duct up to 50 feet with air duct adapter kit.
- 2.6.3 Duct up to 100 feet with air duct adapter and booster fan kits.

2.7 OPERATING REQUIREMENTS

- 2.7.1 Requires provision for condensate draining; if a suitable drain is not available, a condensate pump is required.
- 2.7.2 Electrical: 208/240 Vac 60 Hz, single phase 30 amp power supply.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Coordinate drain requirements of plumbing equipment provided by Mechanical Division and or Owner with location of drains specified in Section 22 13 00.

3.2 INSTALLATION

- 3.2.1 Provide heat pump domestic hot water heater.
- 3.2.2 Secure heater in place, level and plumb, on a concrete housekeeping pad, and:
 - 3.2.2.1 pipe temperature/pressure relief valve outlet to drain.
 - 3.2.2.2 pipe drain valve outlet to drain.
 - 3.2.2.3 coordinate installation with electrical trade who will connect heater with power wiring.

- 3.2.2.4 Ensure housekeeping pad is keyed to structure and tank assembly is secured to structure by slack cable restraints. Refer to Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.2.2.5 Install inlet and outlet manifolds supplied with heaters.
- 3.2.2.6 Set thermostat to produce 48.8°C (120°F) hot water.

3.3 SYSTEM STARTUP

- 3.3.1 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.3.2 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical. Submit a copy of the letter prior to Substantial Performance of the Work.

3.4 TRAINING

- 3.4.1 Include for 2 hours of on-site training for 2 groups of 6 people. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Plumbing fixtures and related components.

1.2 SUBMITTALS

- 1.2.1 Submit product data sheets (fixture cuts) for all plumbing fixtures and fittings, including accessories.
- 1.2.2 Product Data: Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports and indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.
- 1.2.3 Wiring Diagrams: Power, signal, and control wiring.
- 1.2.4 Submit fixture manufacturer's standard colour charts for all fixtures where colours are available, but a particular colour is not specified.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Operation and maintenance data.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Subject to compliance with requirements, manufacturers that may be incorporated into the Work include, but are not limited to, following:
 - 2.1.1.1 Flush Valves:
 - (1) Sloan;
 - (2) Delta Commercial;
 - (3) Zurn Industries;
 - (4) Moen Commercial.
 - 2.1.1.2 Plumbing Brass:
 - (1) Sloan;
 - (2) Acorn Engineering;
 - (3) American Standard;
 - (4) Delta Commercial;
 - (5) Chicago Faucet;
 - (6) Moen Commercial.
 - 2.1.1.3 Stainless Steel Sinks:
 - (1) Franke Commercial;
 - (2) Novanni Commercial;
 - (3) Aristaline;
 - (4) Arch Metal Ind.
 - 2.1.1.4 Mop Sinks:
 - (1) Stern Williams;
 - (2) Acorn Engineering;

- (3) Zurn Industries.
 - 2.1.1.5 Drain Fittings, Angle Supplies, and Traps:
 - (1) McGuire;
 - (2) American Standard;
 - (3) Delta Commercial;
 - (4) Zurn Industries.
 - 2.1.1.6 Fixture Carriers:
 - (1) Watts Industries;
 - (2) Jay R. Smith;
 - (3) Zurn Industries.
 - 2.1.1.7 Water Closets, Lavatories, and Urinal:
 - (1) American Standard;
 - (2) Zurn Industries;
 - (3) Kohler.
 - 2.1.1.8 Thermostatic Mixing Valves:
 - (1) Lawler;
 - (2) Delta Commercial;
 - (3) Leonard.
 - 2.1.1.9 Shower and Associated Trim:
 - (1) American Standard;
 - (2) Delta Commercial;
 - (3) Zurn Industries;
 - (4) Moen Commercial.
 - 2.1.1.10 Toilet Seats:
 - (1) Olsonite;
 - (2) Centoco;
 - (3) Bemis Commercial.
 - 2.1.1.11 Electronic "No Touch" Flush Valves:
 - (1) Sloan;
 - (2) Delta Commercial;
 - (3) Zurn Industries;
 - (4) Moen Commercial.
 - 2.1.1.12 Electronic "No Touch" Faucets:
 - (1) Sloan;
 - (2) Delta Commercial;
 - (3) Zurn Industries;
 - (4) Moen Commercial.
-

2.2 GENERAL RE: PLUMBING FIXTURES AND FITTINGS

- 2.2.1 Fixtures and fittings, where applicable, are to be in accordance with requirements of CAN/CSA B45 Series, General Requirements for Plumbing Fixtures, including supplements, ASME A112.1.18.1/CSA B125.1, Plumbing Supply Fittings, and CSA B125.3, Plumbing Fittings.
- 2.2.2 Barrier-free fixtures and fittings are to be in accordance with governing Code requirements.
- 2.2.3 Unless otherwise specified, vitreous china, porcelain enamelled, and acrylic finished fixtures are to be white.
- 2.2.4 Unless otherwise specified, fittings and piping exposed to view are to be chrome plated and polished.
- 2.2.5 Fittings located in areas other than private washrooms are to be vandal-proof.
- 2.2.6 Fixture carriers are to be suitable in all respects for the fixture they support and construction in which they are located.
- 2.2.7 Floor flanges for floor mounted water closets are to be cast iron or brass, secured to floor to prevent movement and complete with a wax seal and brass or stainless steel bolts, nuts, and washers. Plastic floor flanges will not be acceptable.
- 2.2.8 Proper seal to mate with fixture carrier flange and produce a water-tight installation.
- 2.2.9 Exposed traps for fixtures not equipped with integral traps, such as lavatories, are to be adjustable chrome plated cast brass "P" traps with cleanouts, minimum 17 gauge chrome plated tubular extensions, and chrome plated escutcheons, all to suit fixture type and drain connection.
- 2.2.10 Concealed traps for fixtures not equipped with integral traps, such as counter sinks, are to be adjustable cast brass with cleanout plugs, all to suit fixture type and drain connection.
- 2.2.11 Exposed supplies for fixtures which do not have supply trim/fittings with integral stops, i.e. lavatories, are to be solid chrome plated brass angle vales with screwdriver stops for public areas, wheel handle stops for private areas, flexible stainless steel risers, and stainless steel or chrome plated steel escutcheons, all arranged and sized to suit fixture.
- 2.2.12 Water piping as specified, complete with ball type shut-off valves as specified with water piping, or Dahl Bros. Canada Ltd. ¼ turn Mini Ball Valves.

2.3 PLUMBING FIXTURES AND FITTINGS

- 2.3.1 WC-1 - TOILET - FLOOR MOUNTED WITH FLOOR OUTLET
 - 2.3.1.1 American Standard 288CA114.020 Toilet - GLENWALL, Tank type Toilet, Floor mounted with floor outlet, Ultra High Efficiency UHET 4.2 LPF (1.1 GPF), White finish Vitreous china, EverClean antimicrobial surface, Elongated bowl, Minimum 305 mm (12") rough-in from wall to the centre of waste outlet, Siphon action bowl with direct-fed jet, Manual, Polished chrome left-hand trip lever, Tank not lined, Without tank cover locking device, Gravity-assisted flush, Tank coupling components, Fully-glazed 51 mm (2") trapway, PowerWash rim scrubs bowl with pressurized water every flush, Sanitary bar on bowl, Toilet seat not included, Two (2) colour-matched bolt caps, 381 mm (15") wide, 756 mm (29-3/4") from finished wall, 762 mm (30") high Compliances: CALGreen compliant, ASME A112.19.2 compliant, California Energy Commission (CEC) compliant, CSA B45.1 compliant, EPA WaterSense compliant.
 - 2.3.1.2 Centoco 500STSCCFE-001 Seat - FAST-N-LOCK, for elongated bowl, open front, heavy-duty, for commercial applications, Polypropylene, Toilet seat, Less seat cover, Plastic commercial check hinges, and Stainless steel hinge pin, Specified in White finish, FAST-N-LOCK mounting system takes the guess

- work out when tightening the hardware. The specially designed fasteners in click" when the appropriate torque is reached. The bolt and nut material shall be stainless steel, Dimensions:25 mm (1") high, 473 mm (18-5/8") long, 371 mm (14-5/8") wide.
- 2.3.1.3 McGuire LFBV172 Supply - Lead Free, with Chrome-plated finish, Convertible quarter-turn supply , Toilet, two 13 mm (1/2") copper sweat x 10 mm (3/8") outer Ø brass ball valve connection, 2 deep bell flange, Convertible loose key handle, extension is 127 mm (5") length, 304 mm (12") copper flexible risers.
- 2.3.2 WC-2 - TOILET - FLOOR MOUNTED WITH FLOOR OUTLET
- 2.3.2.1 American Standard 288AA114.020 Toilet - H2OPTIMUM, Tank type Toilet, Floor mounted with floor outlet, Ultra High Efficiency UHET 4.2 LPF (1.1 GPF), White finish Vitreous china, EverClean antimicrobial surface, Elongated bowl, Right Height rim at 419 mm (16-1/2"), Minimum 305 mm (12") rough-in from wall to the centre of waste outlet, Siphon jet flush action, Manual, Polished chrome left-hand trip lever (7381192-0020A), Tank not lined, Without tank cover locking device, Gravity-assisted flush, Tank coupling components, 229 x 203 mm (9" x 8") water surface area, Fully-glazed 51 mm (2") trapway, PowerWash rim scrubs bowl with pressurized water every flush, Sanitary bar on bowl, Toilet seat not included, Two (2) colour-matched bolt caps, 381 mm (15") wide, 756 mm (29-3/4") from finished wall, 800 mm (31-1/2") high
Compliances: CALGreen compliant, ASME A112.19.2 compliant, California Energy Commission (CEC) compliant, CSA B45.1 compliant, EPA WaterSense compliant.
- 2.3.2.2 Centoco 820STSFE-001 Seat - FAST-N-LOCK, For elongated bowl, Open front, Heavy-duty, For commercial applications, Polypropylene, Toilet seat, With seat cover, Plastic commercial check hinges, and Stainless steel hinge pin, Specified in White finish, FAST-N-LOCK mounting system takes the guess work out when tightening the hardware. The specially designed fasteners in click" when the appropriate torque is reached. The bolt and nut material shall be stainless steel, Dimensions:25 mm (1") high, 470 mm (18-1/2") long, 362 mm (14-1/4") wide
- 2.3.2.3 McGuire LFBV172 Supply - Lead Free, with Chrome-plated finish, Convertible quarter-turn supply , Toilet, Two 13 mm (1/2") copper sweat x 10 mm (3/8") outer Ø brass ball valve connection, 2 deep bell flange, Convertible loose key handle, extension is 127 mm (5") length, 304 mm (12") copper flexible risers.
- 2.3.3 L-1 - LAVATORY
- 2.3.3.1 American Standard 0475047.020 Basin - Drop-in Lavatory, Vitreous china, White finish, Single hole centreset, Front overflow, With faucet ledge, Overall Dimensions: 518 mm (20-3/8") long, 441 mm (17-3/8") wide, 178 mm (7") high, Bowl Dimensions: 406 mm (16") long, 254 mm (10") wide, 143 mm (5-5/8") deep
- 2.3.3.2 Sloan EAF-275-SOL-ISM-CP-0.5GPMGPM-AER-IR-IQ-FCT Faucet - OPTIMA, counter mounted, automatic no-touch, solar powered, lavatory faucet, polished chrome finish, single hole centreset, metal, water supply connection with flexible high pressure hose and strainer, 1.9 LPM (0.5 GPM) maximum flowrate, aerated spray outlet, fixed spout, 110 mm (4-5/16") spout reach, 136 mm (5-11/32") high, double infrared sensors with automatic setting feature, above deck control access, 6 VDC lithium battery back-up power source, Integrated side mixer, IQ Click.
- 2.3.3.3 Lawler 570-86820 Mixing Valve - Point of Use and Master controlled fixtures, Thermostatic master water mixing control valve, lead free brass body construction, Nickel plated finish, 1.9-30 LPM (0.5-8 GPM) range for flowrate, To adjust the mixed outlet temperature of the valve, remove the cap to gain access to the adjusting spindle. The spindle should be rotated-clockwise to
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- reduce the temperature, counter-clockwise to increase the temperature until the desired set point is reached, 11 LPM (3 GPM) tempered flowrate @ 5 PSI pressure drop, The temperature is adjusted with the help of Spindle, 4-7/8" (124 mm) Height, ASSE 1070 approved Certified to CSA B125.3 for ASSE 1070 applications, 3/8" MNPT (9.5 mm) inlet, 95°F-115°F outlet water temperature range, 3/8" MNPT (9.5 mm) outlet, internal checks, Offers choice of temperature settings from 95°F through 115°F, 125 psi max hydrostatic pressure, ±20% pressure variation, 40-80°F, 10°F, 180°F max, ±5°F, Protects against scalding and chilling, 7 GPM flowrate @ 45 PSI.
- 2.3.3.4 McGuire LFCK165LK Supply - ICV DEFENDER, Lead Free, with Chrome-plated finish, Integral check supply kit, Faucet, Pipe to compression connection, 3/8" I.P.S x 3/8" O.D connection, Shallow wall flange, Loose key handle, Full turn brass stem, 305 mm (12") chrome-plated risers, Purple EPDM peroxide cured washers. Codes and compliances: NSF/ANSI 61 & 372, UPC.
- 2.3.3.5 McGuire 155A Fixture Drain - Straight drain, Cast brass, Chrome-plated finish, Open grid PO plug, 7/32" (5.5 mm) Ø holes size, 17 gauge 32 mm (1-1/4") Ø tailpiece diameter, 17 gauge 152 mm (6") long, Brass locknut, Heavy rubber basin washer Fiber friction washer, ASME A112.18.2 CSA B125.2, CSA compliant.
- 2.3.3.6 McGuire 8872CB P-Trap - Heavy cast brass, 292 mm (11-1/2") distance, With cleanout plug, Steel box flange, Neoprene gasket, slipnuts, 17 gauge seamless tubular wall bend, ASME A112.18.2 CSA B125.2, CSA compliant.
- 2.3.4 L-2 – BF Lavatory
- 2.3.4.1 American Standard 9960001.020 Basin - MEZZO, Semi-countertop Lavatory, Fine fire clay, White finish, Single hole centreset, Rear overflow, with faucet ledge, mounting kit supplied, Overall Dimensions: 559 mm (22") long, 546 mm (21-1/2") wide, 172 mm (6-25/32") high, Bowl Dimensions: 483 mm (19") long, 381 mm (15") wide, 175 mm (6-7/8") deep.
- 2.3.4.2 Sloan EAF-275-SOL-ISM-CP-0.5GPMGPM-AER-IR-IQ-FCT Faucet - OPTIMA, counter mounted, automatic no-touch, solar powered, lavatory faucet, polished chrome finish, single hole centreset, metal, water supply connection with flexible high pressure hose and strainer, 1.9 LPM (0.5 GPM) maximum flowrate, aerated spray outlet, fixed spout, 110 mm (4-5/16") spout reach, 136 mm (5-11/32") high, double infrared sensors with automatic setting feature, above deck control access, 6 VDC lithium battery back-up power source, Integrated side mixer, IQ Click.
- 2.3.5 MS-1 - MOP SINKS
- 2.3.5.1 Stern-Williams #HL-1810 HiLow, 24" x 24" x 12" (610 mm x 610 mm x 305 mm) floor mounted pre-cast terrazzo mop sink with cast brass drain assembly, stainless steel strainer, one-piece integral stainless-steel cap on all four (4) sides, Hose and wall hook, Mop hanger, Splash Catcher panel, 20 gauge, type 304 stainless steel.
- 2.3.5.2 American Standard 8344.212.004 Faucet - Manual, Wall Mounted, 8", Cast Brass Construction, Mop Sink, Rough Chrome, 15 GPM at 60 PSI, 6" cast brass spout with vacuum breaker, 10-1/4" (259 mm), Less Supply, Ceramic Disc Valve Cartridge, Less Drain, Metal lever handles, Two Handles, ASME A112.18.1, CSA B125.
- 2.3.5.3 Trap - 3" (75 mm) diameter cast iron or rough copper "P" trap.
- 2.3.6 S-1 – COUNTER MOUNTED, DROP-IN, COMMERCIAL SINK
- 2.3.6.1 Franke Commercial LBD6408P-1-3 Sink - Double compartment sink, 203 mm (8") centreset, Commercial sinks, with overall dimension 794 mm (31-1/4") long, 521 mm (20-1/2") wide, 203 mm (8") high, constructed from 18 gauge Type 304 Stainless steel, Left bowl is 356 mm (14") long and right bowl is 356 mm (14")
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- long, Left bowl is 406 mm (16") wide and right bowl is 406 mm (16") wide, Left bowl is 203 mm (8") deep and right bowl is 203 mm (8") deep, Polished to #4 satin finish, Factory installed EZ TORQUE fasteners, Factory applied rim seal, Centre back waste location, 38 mm (1-1/2") (DN38) brass tailpiece, standpipe with guard, 89 mm (3-1/2") crumb cup strainer, Undercoated to reduce condensation and resonance. Codes and Compliances: ASME A112.19.3 compliant, CSA B45.4 compliant.
- 2.3.6.2 Chicago Faucets 431-ABCP Faucet - Counter mounted, Manual, Single handle, Sink faucet, Polished chrome finish, 203 mm (8") centreset, Lead Free ANSI/NSF 61 compliant, ECAST brass construction, Ceramic cartridge, 5.7 LPM (1.5 GPM) maximum flowrate, Pressure compensating non-aerated laminar spray outlet, Tubular cast brass spout, 229 mm (9") spout reach, 152 mm (6") high, Lever handle, 13 mm (1/2") NPSM supply inlet.
- 2.3.6.3 McGuire LFCK170LK Supply - ICV DEFENDER, Lead Free, with Chrome-plated finish, Integral check supply kit w/5" sweat extension, Faucet, Sweat to compression connection, 1/2" Sweat w/5" Sweat extension x 3/8" O.D connection, Deep bell wall flange, Loose key handle, Full turn brass stem, 305 mm (12") chrome-plated risers, Purple EPDM peroxide cured washers, Codes and compliances: NSF/ANSI 61 & 372, UPC.
- 2.3.6.4 McGuire 8912CB P-Trap - Heavy cast brass, Adjustable p-trap, 292 mm (11-1/2") length, With cleanout plug, Steel box flange, Neoprene gasket, Seamless tubular brass bend, Slipnuts.
- 2.3.7 S-2 – FLOOR MONTED, SCULLERY SINK
- 2.3.7.1 Franke Commercial TL-2454-1-2 Sink - Triple compartment sink, 203 mm (8") centreset, Scullery sink, with overall dimension 1457 mm (57-3/8") long, 691 mm (27-3/16") wide, 1118 mm (44") high, constructed from Grade 18-10 16 gauge Type 304 Stainless steel, Left bowl is 457 mm (18") long, middle bowl is 457 mm (18") long and right bowl is 457 mm (18") long, Left bowl is 610 mm (24") wide, middle bowl is 610 mm (24") wide and right bowl is 610 mm (24") wide, Left bowl is 356 mm (14") deep, middle bowl is 356 mm (14") deep and right bowl is 356 mm (14") deep, Finished with rolled rim, Polished to #4 satin finish, With backsplash, Radius coved corners on front and back only, Less overflow, Stainless steel tubular legs with adjustable feet for leveling, Centre waste location, 38 mm (1-1/2") (DN38) brass tailpiece, 89 mm (3-1/2") crumb cup strainer, waste fitting included, Codes and Compliances: ASME A112.19.3 compliant, CSA B45.4 compliant.
- 2.3.7.2 Chicago Faucets 510-GWSLXKCAB Faucet - Wall-hung, Manual, Two handles, Pre-rinse fitting, Chrome plated finish, 184 mm–222 mm (7-1/4" - 8-3/4") adjustable centreset, Lead Free ANSI/NSF 61 and ANSI/NSF 372 compliant, ECAST brass construction, 1/4 turn ceramic cartridge with integrated check valve, 3.8 LPM (1.0 GPM) flow rate @60 psi pre-rinse spray valve, Spray outlet, Pre-rinse spout, Pull down, 292 mm (11-1/2") spout reach, 1006 mm (39-5/8") high, Pre-rinse spout and valve consisting of 584 mm (23") riser with spring guide, 1118 mm (44") flexible stainless steel hose with insulated handle, pipe strap and hook assembly, Vandal-resistant 60 mm (2-3/8") lever handle with indexed buttons, 13 mm (1/2") NPT female thread inlet.
- 2.3.7.3 McGuire LFCK170LK Supply - ICV DEFENDER, Lead Free, with Chrome-plated finish, Integral check supply kit w/5" sweat extension, Faucet, Sweat to compression connection, 1/2" Sweat w/5" Sweat extension x 3/8" O.D connection, Deep bell wall flange, Loose key handle, Full turn brass stem, 305 mm (12") chrome-plated risers, Purple EPDM peroxide cured washers, Codes and compliances: NSF/ANSI 61 & 372, UPC.
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- 2.3.7.4 McGuire 8912CB P-Trap - Heavy cast brass, Adjustable p-trap, 292 mm (11-1/2") length, With cleanout plug, Steel box flange, Neoprene gasket, Seamless tubular brass bend, slipnuts.
- 2.3.8 SH-1 - PRESSURE BALANCING SHOWER SYSTEM WITH SHOWER HEAD, HAND SPRAY, AND DIVERTER – BARRIER FREE
 - 2.3.8.1 Chicago Faucets SH-PB1-17-042 Complete Shower Trim - Polished Chrome, Pressure balancing shower system with shower head, hand spray, and valve trim options, 1.5 GPM (5.7 LPM) flow rate @ 80 psi, Showerhead with adjustable spray, With Hand Shower, 1.5 GPM (5.7 LPM) flow rate, Diverter valve with indexed wall flange.
 - 2.3.8.2 Watts #FD-100-A Floor Drain, 2" outlet, epoxy coated cast iron, anchor flange, adjustable round nickel bronze strainer, reversible clamping collar with primary and secondary weepholes.
 - 2.3.8.3 Trap – provide P-Trap, same material as the connecting pipe drain.

2.4 CAULKING

- 2.4.1 General Electric Series SCS-1200 Silicone Construction Sealant or Dow Corning 780 silicone rubber sealant with primers as recommended by sealant manufacturer. Caulking colour(s) for coloured fixtures other than white, if any, will be selected by the Consultant from sealant manufacturer's standard colour range.

3 EXECUTION

3.1 INSTALLATION OF PLUMBING FIXTURES AND FITTINGS

- 3.1.1 Provide required plumbing fixtures and fittings.
- 3.1.2 Connect plumbing fixtures and fittings with piping sized in accordance with drawing schedule. Refer to manufacturer's published connection (rough-in) requirements. Where manufacturer requires piping connection larger than shown on drawing schedule, provide piping accordingly:
- 3.1.3 Confirm exact location of plumbing fixtures and trim prior to roughing-in. Refer to architectural plan and elevation drawings.
- 3.1.4 When installation is complete, check, and test operation of each fixture and fitting. Adjust or repair as required.
- 3.1.5 For barrier-free fixtures, comply with mounting height and other requirements of governing Code(s).
- 3.1.6 For barrier-free water closets utilizing manual flush controls, controls to be installed so that it is operable from the transfer side of the fixture.
- 3.1.7 Supply templates for counter mounted fixtures and trim and hand to trades who will cut the counter. Ensure openings in counter are properly located.
- 3.1.8 Locate control panels for electronic faucets under lavatories and recessed into wall. Coordinate panel installations with electrical trade who will provide 115 V power wiring to panels. Install flexible conduit (supplied with box) and extend cord from faucet through the flexible conduit to control box. Connect hot and cold water piping to mixing valve in each box, and tempered water piping from each mixing valve to faucet. Set mixing valve maximum temperature limit stops to 43°C (110°F) after domestic water systems (hot and cold) are complete. Ensure each programmable controller is properly programmed and water off after deactivation is set for 3 seconds.
- 3.1.9 For electronic flush valves, locate transformer in ceiling space above electronic units to be served. Coordinate locations with electrical trade who will provide 120 V line supply to transformers. Provide low voltage wiring from transformers to each electronic flush valve

terminal point. Electrical line supply and low voltage wiring is to be concealed and access to transformer must be provided for servicing.

- 3.1.10 Protect baths from damage during construction and finishing work. Unless otherwise specified, pack concealed voids under baths with batt type glass fibre insulation as baths are installed.
- 3.1.11 Protect shower bases from damage during construction and finishing work.
- 3.1.12 Confirm exact mixing valve and shower head locations prior to roughing-in.
- 3.1.13 Install refrigerated drinking fountains in accordance with manufacturer's instructions. Plug into a wall receptacle provided as part of electrical work. Coordinate receptacle installation with electrical trade on site.
- 3.1.14 For emergency showers, install so bottom of shower head is approximately 2 m (82 in) above floor, and approximately 400 mm (16 in) out from the wall. Wall mount mixing valve approximately 1.5 m (5 ft) above floor and adjacent shower head. Set valve temperature limit stop to 35°C (95°F). Ensure valve is open and exposed piping is chrome plated or stainless steel.
- 3.1.15 Install eye wash fixtures in accordance with manufacturer's instructions. Ensure exposed piping is painted.
- 3.1.16 Wall mount mixing valves for emergency fixtures approximately 1.5 m (5 ft) above floor and secure in place. Check and confirm valve operation and temperature of tempered water supply. Provide cabinets. Identify each cabinet and hand 3 identified cabinet keys to Consultant prior to Substantial Performance of the Work.
- 3.1.17 Set mop service basins on floor over drain piping and connect to roughed-in service. Install wall supply trim and any accessories specified.

3.2 CAULKING AT PLUMBING FIXTURES AND FITTINGS

- 3.2.1 Caulk around plumbing fixtures and fittings where they contact walls, floors, and any other building surface.
- 3.2.2 Clean areas/surfaces to be caulked and prime in accordance with sealant manufacturer's instructions. Where damage to a building surface may occur, mask surface to prevent damage and ensure a clean exact edge to the caulking bead.
- 3.2.3 Apply caulking using a gun with proper size and shape of nozzle and force sealant into joints to ensure good surface contact and a smooth and even finished bead of sealant.
- 3.2.4 If joints have been masked sealant may be tooled in a continuous stroke to obtain complete void filling. Remove masking tape immediately after tooling and before sealant begins to skin.

3.3 DISHWASHER CONNECTIONS

- 3.3.1 Provide roughed-in water and drain connections for Owner supplied dishwasher consisting of:
 - 3.3.1.1 15 mm (1/2") dia. domestic hot water connection with a Dahl "Mini-Ball" valve with hose end and water hammer arrestor;
 - 3.3.1.2 40 mm (1-1/2") dia. DWV copper drain connection with "P" trap and cleanout plug.

3.4 CLOTHES WASHER CONNECTIONS

- 3.4.1 Provide roughed-in water and drain connections for Owner supplied clothes washer consisting of:
 - 3.4.1.1 15 mm (1/2") dia. piping connection for both hot and cold water, each terminated in a Dahl "Mini-Ball" Valve with hose end and water hammer arrestor;

- 3.4.1.2 50 mm (2") dia. standing waste with a height to suit the washer drain and complete with a "P" trap.

3.5 GEAR EXTRACTOR CONNECTIONS

- 3.5.1 Provide roughed-in water and drain connections for Owner supplied clothes washer consisting of:
 - 3.5.1.1 25 mm (1") dia. piping connection for both hot and cold water, each terminated in a Dahl "Mini-Ball" Valve with hose end and water hammer arrestor; include for additional connection to hot water inlet for soap chute.
 - 3.5.1.2 75 mm (3") dia. drain down to trench.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Eyewash stations.
- 1.1.2 Emergency fixture water-tempering equipment.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 22 11 00 – Facility Water Distribution.

1.3 REFERENCES

- 1.3.1 ASME A112.6.1, Supports for Off-the-Floor Plumbing Fixtures for Public Use.
- 1.3.2 ASME A112.18.1, Plumbing Fixture Fittings.
- 1.3.3 CSA B45 Series, Plumbing fixtures.
- 1.3.4 CSA B125, Plumbing fittings.

1.4 ACTION SUBMITTALS

- 1.4.1 Section 01 33 00: Procedures for submittals.
- 1.4.2 Product Data: Provide catalogue illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- 1.4.3 Samples: Submit two sink supply fittings.
- 1.4.4 Shop drawing shall show illustrations, dimension drawings, and detail descriptions of fixtures and trim.

1.5 INFORMATIONAL SUBMITTALS

- 1.5.1 Section 01 33 00: Procedures for submittals.
- 1.5.2 Manufacturer's Instructions: Indicate installation methods and procedures.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 Section 01 77 00: Procedures for submittals.
- 1.6.2 Maintenance Data: Include fixture trim exploded view and replacement parts lists.
- 1.6.3 Turn over keys, tools, maintenance instructions, and maintenance stock to Owner.
- 1.6.4 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

- 1.7.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years experience.

1.8 REGULATORY REQUIREMENTS

- 1.8.1 Products Requiring Electrical Connection: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.9 DELIVERY, STORAGE, AND HANDLING

- 1.9.1 Section 01 60 00: Transport, handle, store, and protect products.
 - 1.9.2 Accept fixtures on site in factory packaging. Inspect for damage.
 - 1.9.3 Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.
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2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Bradley.
- 2.1.2 Guardian.
- 2.1.3 Haws.
- 2.1.4 Speakman.

2.2 GENERAL

- 2.2.1 Fixtures and trim shall be CSA approved, in accordance with CSA B45. Finished surfaces shall be clear, smooth, and bright, and guaranteed not to graze, discolour, or scale. Completely install fixtures and connect to drain, vent, domestic hot water, and domestic cold water supply piping, to approval of authorities.

2.3 WALL MOUNTED EYEWASH STATIONS

- 2.3.1 EW-1 - Eye/Face Wash, Wall Mounted, Stainless Steel Bowl
 - 2.3.1.1 Guardian #G1814P-T, Wall Mounted, eye wash, 11-1/2" (292 mm) diameter, orange ABS plastic bowl, two (2) GS-Plus spray heads with fliptop dust cover and filter, powder coated cast aluminum flag handle activation, 1/2" (13 mm) IPS chrome plated brass stay-open ball valve with Teflon seal, heavy duty cast aluminum wall bracket with corrosion resistant powder coated finish, chrome plated brass tailpiece and trap with 1-1/2" (38 mm) IPS waste connection, 1-1/4" (32 mm) NPT female outlet - Unit is third party certified by IAPMO to meet ANSI Z358.1-2014, the Uniform Plumbing Code cUPC and the National Plumbing Code of Canada. For Emergency Thermostatic Mixing Valve, Lawler model # 911E/F.

2.4 WATER TEMPERING EQUIPMENT

- 2.4.1 Emergency Tempered Water Mixer. Lawler #911E/F, Emergency Thermostatic Mixing Valve for Eyewash or Eye/Face Wash, lead-free brass and stainless steel design, vandal-resistant temperature adjustment, stainless steel sliding piston control device allow cold flow through both the fixed and variable bypass, 13 mm (1/2") NPT outlet, positive hot water shut-off, liquid-filled thermostatic motor control mechanism, 29°C (84.2°F) factory set temperature, standard 69.8°F (21°C) - 89.6°F (32°C) temperature range, 26 LPM (6.9 GPM) flow capacity at 30 psi (207 KPa) pressure drop across the valve, 7.57 LPM (2.0 GPM) minimum flow rate, 18 LPM (4.8 GPM) bypass flow rate at 30 psi. (see 911E/F).

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Section 01 73 29: Verification of existing conditions before starting work.
- 3.1.2 Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- 3.1.3 Verify that electric power is available and of the correct characteristics.
- 3.1.4 Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.

3.2 PREPARATION

- 3.2.1 Rough-in fixture piping connections to minimum sizes indicated in fixture rough-in schedule for each fixture.
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- 3.2.2 Plumbing Fixture Installation Heights:
 - 3.2.2.1 Confirm all mounting heights with the Architect prior to roughing-in. Generally, heights for wall hung components are indicated on the drawings. Refer to Architectural drawings for counter mounted fixture heights.

3.3 INSTALLATION

- 3.3.1 Completely connect up plumbing fixtures. Protect surface of plumbing fixtures from damage before, during and after their installation and until Work is completed and accepted. Do not use plumbing fixtures for storage of tools or materials nor as a support or platform. Take every precaution during period of construction to avoid damage to fixtures and fittings. Clean fixtures, and trim immediately prior to building being taken over by Owner.
- 3.3.2 Provide necessary plates, brackets or wall carriers, cleats and supports for rigidly securing fixtures in place. Accurately lay-out roughing-in. Offsets will not be accepted.
- 3.3.3 Visible parts of trimmings of fixtures including faucets, escutcheons, wastes, strainers, traps, shower heads, supplies and stops, shall be heavily chrome plated.
- 3.3.4 Provide a wheel handle or screwdriver stop valve on hot and cold water supply to every fixture on job, in addition to valves or faucets on fixture itself. Provide shut-offs at emergency mixing valve.
- 3.3.5 Install each fixture with trap, easily removable for servicing and cleaning.
- 3.3.6 Provide chrome plated rigid or flexible supplies to fixtures with loose key stops, reducers, and escutcheons.
- 3.3.7 Install components level and plumb.
- 3.3.8 Install and secure fixtures in place with wall supports.
- 3.3.9 Seal fixtures to wall and floor surfaces with sealant as specified in Section 07 92 00, colour to match fixture.
- 3.3.10 Solidly attach water closets to floor with lag screws. Lead flashing is not intended hold fixture in place.

3.4 TESTING AND ADJUSTING

- 3.4.1 Section 01 73 29: Adjusting installed work.
- 3.4.2 Set field-adjustable temperature set points of temperature-actuated water mixing valves. Adjust set point within allowable temperature range.
- 3.4.3 Test and adjust installation.
- 3.4.4 Remove and replace malfunctioning thermostatic mixing valves and retest.

3.5 CLEANING

- 3.5.1 Repair or replace defective work, including damaged fixtures and components.
- 3.5.2 Clean unit surfaces, test fixtures, and leave in ready-to-use condition.
- 3.5.3 Section 01 74 19: Cleaning installed work.
- 3.5.4 Clean plumbing fixtures and equipment.

3.6 PROTECTION

- 3.6.1 Section 01 73 29: Protecting installed work.
- 3.6.2 Protect units with water-resistant temporary covering. Do not allow temporary use of plumbing fixtures unless approved in writing by Architect. Remove protection at Substantial Completion and dispose.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Bottle fillers.

1.2 REFERENCES

- 1.2.1 Air Conditioning and Refrigeration Institute (ARI):
 - 1.2.1.1 ARI 1010-2002, Self-Contained, Mechanically Refrigerated Drinking-Water Coolers.
- 1.2.2 CSA Group:
 - 1.2.2.1 CAN/CSA B45 series, Plumbing Fixtures.
 - 1.2.2.2 CAN/CSA-B125, Plumbing Fittings.
 - 1.2.2.3 CAN/CSA-B651, Barrier-Free Design.
 - 1.2.2.4 CSA C22.2 No. 120-13 (R2023), Refrigeration equipment.

1.3 SUBMITTALS

- 1.3.1 In accordance with Section 01 33 00.
- 1.3.2 Indicate for all fixtures:
 - 1.3.2.1 Dimensions, construction details, roughing-in dimensions.

1.4 CLOSEOUT SUBMITTALS:

- 1.4.1 Provide maintenance data including monitoring requirements for incorporation into manuals specified in Section 01 77 00.
- 1.4.2 Include:
 - 1.4.2.1 Description of fixtures and trim, giving manufacturer's name, type, model, year, capacity.
 - 1.4.2.2 Details of operation, servicing, maintenance.
 - 1.4.2.3 List of recommended spare parts.

1.5 QUALITY ASSURANCE

- 1.5.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years experience.

1.6 DELIVERY, STORAGE, AND HANDLING

- 1.6.1 Section 01 60 00: Transport, handle, store, and protect products.
- 1.6.2 Accept fixtures on site in factory packaging. Inspect for damage.
- 1.6.3 Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.7 WARRANTY

- 1.7.1 Provide a written guarantee, signed, and issued in the name of the Owner, against defective materials and workmanship for a period of 1 year from the date of Substantial Completion.
-

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Elkay.
- 2.1.2 Haws.
- 2.1.3 Oasis.

2.2 MANUFACTURED UNITS

- 2.2.1 Fixtures: manufacture in accordance with CAN/CSA-B45 series.
- 2.2.2 Trim, fittings: manufacture in accordance with CAN/CSA-B125.
- 2.2.3 Exposed plumbing brass to be chrome plated.
- 2.2.4 Quantity, locations: Architectural drawings to govern.

2.3 NON-REFRIGERATED BOTTLE FILLERS

- 2.3.1 Manufacturers:
 - 2.3.1.1 Elkay ezH2O, model EZWSSM (basis of design).
- 2.3.2 Description:
 - 2.3.2.1 Elkay ezH2O Bottle Filling Station Surface Mount Non-Filtered Non-Refrigerated Stainless. Features shall include Antimicrobial, Green Ticker, Hands Free, Laminar Flow, Real Drain. Electronic Bottle Filler Sensor activation. Product shall be Wall Mount (On Wall), for Indoor applications, serving 1 station(s). Unit shall be certified to UL 399 and CAN/CSA C22.2 No. 120.
- 2.3.3 Features:
 - 2.3.3.1 Finish: Stainless Steel.
 - 2.3.3.2 Special Features: Antimicrobial, Green Ticker, Hands Free, Laminar Flow, Real Drain.
 - 2.3.3.3 Electrical: grounded electrical cord with plug, 115 V, 1-Ph, 60 Hz, 1 A FLA, rated 15 W.
 - 2.3.3.4 Dimensions: 17-15/16" L x 8-3/16" W x 25-7/16" H.
 - 2.3.3.5 Bubbler Style: No Bubbler.
 - 2.3.3.6 Mounting: Surface wall mounting, ideal for installations with limited wall depth.
 - 2.3.3.7 Chilling Capacity: Non-refrigerated.
 - 2.3.3.8 Installation Location: Indoor.
 - 2.3.3.9 Filtered: No.
 - 2.3.3.10 Code Compliance: ADA, ICC A117.1, CAN/CSA C22.2 No. 120., NSF 372 (lead free), NSF 61, UL 399.
- 2.3.4 Operation sequence: Sanitary no-touch sensor activation with automatic 20 second shut-off timer.

2.4 FIXTURE PIPING

- 2.4.1 Cold water supplies to each fixture:
 - 2.4.1.1 Shut off valve in supply pipes each with handwheel stop, reducers, escutcheon.
 - 2.4.2 Waste:
 - 2.4.2.1 Brass P trap with cleanout on each fixture not having integral trap.
-

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Section 01 73 29: Verification of existing conditions before starting work.
- 3.1.2 Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- 3.1.3 Verify that electric power is available and of the correct characteristics.
- 3.1.4 Confirm that millwork is constructed with adequate provision for the installation of countertop lavatories and sinks.

3.2 PREPARATION

- 3.2.1 Rough-in fixture piping connections to minimum sizes indicated in fixture rough-in schedule for the particular fixture.
- 3.2.2 Plumbing Fixture Installation Heights:
 - 3.2.2.1 Confirm all mounting heights with the Consultant prior to roughing-in. Generally, heights for wall hung components are indicated on the drawings. Refer to Architectural drawings for counter mounted fixture heights.

3.3 INSTALLATION

- 3.3.1 Mounting heights:
 - 3.3.1.1 Standard: to comply with manufacturer's recommendations unless otherwise indicated or specified.
 - 3.3.1.2 Wall-hung fixtures: measured from finished floor.
 - 3.3.1.3 Physically handicapped: to comply with most stringent of either OBC, CAN/CSA B651, or provincial accessibility regulations.
- 3.3.2 Drinking fountains and water coolers:
 - 3.3.2.1 In accordance with ARI 1010.

3.4 ADJUSTING

- 3.4.1 Conform to water conservation requirements specified this section.
- 3.4.2 Adjustments.
 - 3.4.2.1 Adjust water flow rate to design flow rates.
 - 3.4.2.2 Adjust water cooler, drinking fountain flow stream to ensure no spillage.
- 3.4.3 Checks.
 - 3.4.3.1 Refrigerated water coolers: operation, temperature settings.
 - 3.4.3.2 Thermostatic controls. Verify temperature settings, operation of control, limit, and safety controls.

3.5 CLEANING

- 3.5.1 Section 01 74 19: Cleaning installed work.
- 3.5.2 Clean plumbing fixtures and equipment.

3.6 PROTECTION

- 3.6.1 Section 01 73 29: Protecting installed work.
-

3.6.2 Do not permit use of fixtures.

3.7 CLOSEOUT ACTIVITIES

3.7.1 Report checks and verifications in O&M Manual.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 The purpose of this section is to specify Division 23 responsibilities in the commissioning process.
- 1.1.2 Commissioning requires the participation of Division 23 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 13. Division 23 shall be familiar with all parts of Section 01 91 13 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 REFERENCES

- 1.2.1 2023 ASHRAE Handbook – HVAC Applications, Chapter 43 HVAC Commissioning.
- 1.2.2 ASHRAE Guideline 1.1–2007, HVAC&R Technical Requirements for the Commissioning Process.
- 1.2.3 ASHRAE Guideline 0–2019, The Commissioning Process.
- 1.2.4 ASHRAE Guideline 4-2008 – Preparation of O&M Documentation.
- 1.2.5 ASHRAE/IES Standard 202–2018 – Commissioning Process for Buildings and Systems.
- 1.2.6 CSA Z320-11 (R2021), Building Commissioning Standard & Check Sheets.
- 1.2.7 CSA C282:19, Emergency power supply for buildings.
- 1.2.8 CAN/ULC-S1001-11, Integrated Systems Testing of Fire Protection and Life Safety Systems and Fire Protection Commissioning.

1.3 SUBMITTALS

- 1.3.1 Division 23 Contractors shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 01 91 13, Article “Submittals” for additional Division 23 requirements.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Written work products of Division 23 Contractors will consist of the startup and initial checkout plan as described in Section 01 91 13, as well as completed startup, initial checkout, and pre-functional test sheets.

1.5 OPERATIONS AND MAINTENANCE DATA

- 1.5.1 Division 23 Contractors shall compile and prepare documentation for all equipment and systems covered in Section 23 and deliver to the GC for inclusion in the O&M manuals.
- 1.5.2 ASHRAE Guideline 4-2008 is the recommended format.
- 1.5.3 The CxA shall receive a copy of the O&M manuals for review.

1.6 SYSTEMS TO BE COMMISSIONED

- 1.6.1 The following systems shall be commissioned as part of this contract:
 - 1.6.1.1 Identification for M&E Systems and Equipment.
 - 1.6.1.2 Testing, Adjusting and Balancing for Mechanical Systems and Equipment.
 - 1.6.1.3 Mechanical Insulation.
 - 1.6.1.4 Building automation system and all associated control integrators.
 - 1.6.1.5 Instrumentation and Control for Mechanical Systems and Equipment.
 - 1.6.1.6 Sequence of Operations for Mechanical Systems and Equipment.
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- 1.6.1.7 Natural Gas Systems (for Boilers, Water Heaters, AHU burners and Humidifiers).
- 1.6.1.8 Heating and Cooling Water Systems including Heat Exchangers.
- 1.6.1.9 Hydronic Pumps and associated VFD's.
- 1.6.1.10 Air Handling Systems and Equipment.
- 1.6.1.11 Air Terminal Units - CAV/VAV System.
- 1.6.1.12 Air Filtration and HEPA Filters.
- 1.6.1.13 Heating and Cooling Coils.
- 1.6.1.14 Ventilation Systems and Miscellaneous Fans.
- 1.6.1.15 Ventilation controls-CO2 Monitoring.
- 1.6.1.16 Heating Terminals - Fan Coil Units, Unit Heaters/ Forced Flow Heaters, Air Curtains.
- 1.6.1.17 Humidification systems.
- 1.6.1.18 Refrigeration systems-process cooling and building cooling.
- 1.6.1.19 Heat Recovery / Heat Reclaim Systems.
- 1.6.1.20 Duct and piping systems pressure testing.
- 1.6.1.21 HVAC Systems Cleaning.
- 1.6.1.22 Meters and Gauges for Mechanical Systems.
- 1.6.1.23 Heat Tracing.

1.7 COMMISSIONING TEAM

- 1.7.1 The Commissioning Team shall consist of representatives of the following:
 - 1.7.1.1 Owner and the Owner's Operating and Maintenance Staff.
 - 1.7.1.2 Architect.
 - 1.7.1.3 Mechanical Design Engineer.
 - 1.7.1.4 Commissioning Authority or Commissioning Agent (CxA).
 - 1.7.1.5 General Contractor.
 - 1.7.1.6 Mechanical Contractor.
 - 1.7.1.7 Controls Sub-Contractor.
 - 1.7.1.8 Electrical Sub-Contractor.
 - 1.7.1.9 Testing, Adjusting, and Balancing Agency.

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 COMMISSIONING AGENT RESPONSIBILITIES

- 3.1.1 The Commissioning Agent shall:
 - 3.1.1.1 Plan, organize and implement the commissioning process as specified herein.
 - 3.1.1.2 Prepare the commissioning plan, ensure its distribution for review and comment.
 - 3.1.1.3 Revise the commissioning plan as required during construction.
 - 3.1.1.4 Chair commissioning meetings. Prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting.
 - 3.1.1.5 In conjunction with the GC and trades, coordinate commissioning activities.
 - 3.1.1.6 Monitor system verification checks, and ensure the results are documented as the checks are done.
 - 3.1.1.7 Observe select start-ups and initial system operations tests and checks.
 - 3.1.1.8 Direct GC and trades to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes.
 - 3.1.1.9 Witness functional performance tests and document the results.
-

- 3.1.1.10 Prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each.
- 3.1.1.11 Ensure all required O&M manuals, instructions and demonstrations are provided to the Owner's designated operating staff.

3.2 ENGINEER OF RECORD RESPONSIBILITIES

- 3.2.1 Engineer of Record commissioning responsibilities are outlined below:
 - 3.2.1.1 Review the commissioning plan, and participate, as appropriate, in on-site commissioning meetings.
 - 3.2.1.2 At their discretion during the acceptance phase of the commissioning process, be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- 3.3.1 The Owner shall have the following commissioning responsibilities.
 - 3.3.1.1 Ensure the availability of operating staff for all scheduled instruction and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.

3.4 MECHANICAL HVAC CONTRACTOR RESPONSIBILITIES

- 3.4.1 The responsibilities of the HVAC contractor, during construction and acceptance phases in addition to those listed above are (all references apply to commissioned equipment only):
 - 3.4.1.1 Documentation of all procedures performed shall be provided and forwarded to the Engineer of Record. Written documentation must contain recorded test values of all mechanical tests performed per the individual product specification.
 - 3.4.1.2 The start-up service company shall be present during energization of the mechanical equipment. Jobsite and equipment access must be provided by the Mechanical Contractor.
 - 3.4.1.3 The contractor shall supply a power source, specified by the start-up service company, for on-site test equipment.
 - 3.4.1.4 The contractor is to attend all factory witness testing required within the respective specification sections. The contractor is responsible to cover all their costs and include them in their bid.
 - 3.4.1.5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
 - 3.4.1.6 Include the cost of commissioning in the contract price, if not yet included.
 - 3.4.1.7 In each purchase order or subcontract written, include requirements for submittal data, O&M data, and training.
 - 3.4.1.8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process.
 - 3.4.1.9 Contractors shall provide normal cut sheets and shop drawing submittals to the CxA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of pre-functional and functional testing procedures.
 - (1) Typically, this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the

equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

- (2) The Commissioning Agent may request further documentation necessary for the commissioning process. This data request may be made prior to normal submittals.
- 3.4.1.10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CxA for review.
 - 3.4.1.11 Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 - 3.4.1.12 Provide assistance to the CxA in preparation of the specific functional performance test procedures specified in Section 23. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
 - 3.4.1.13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CxA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CxA for review.
 - 3.4.1.14 During the startup and checkout process, execute and document the mechanical-related portions of the pre-functional test sheets provided by the CxA for all commissioned equipment.
 - 3.4.1.15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
 - 3.4.1.16 Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
 - 3.4.1.17 Perform functional performance testing under the direction of the CxA for specified equipment to be commissioned. Assist the CxA in interpreting the monitoring data, as necessary.
 - 3.4.1.18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, PM and A/E and retest the equipment.
 - 3.4.1.19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
 - 3.4.1.20 During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for contractor-generated coordination drawings.
 - 3.4.1.21 Provide training of the Owner's operating personnel as specified.
 - 3.4.1.22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
 - 3.4.1.23 Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.
 - 3.4.1.24 Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
 - 3.4.1.25 Assist and cooperate with the TAB contractor and CxA by:
 - (1) Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
 - (2) Including cost of sheaves and belts that may be required by TAB.
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- (3) Providing test holes in ducts and plenums as directed by TAB to allow air measurements and air balancing. Providing an approved plug.
- (4) Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.
- 3.4.1.26 Install a P/T plug at each water sensor which is an input point to the control system.
- 3.4.1.27 List and clearly identify on the as-built drawings the locations of all air-flow stations.
- 3.4.1.28 Prepare a preliminary schedule for Division 23 pipe and duct system testing, flushing, and cleaning, equipment start-up and TAB start and completion for use by the CxA. Update the schedule as appropriate.
- 3.4.1.29 Notify the PM/GC or CxA depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the PM/GC or CxA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed, and that the CxA has the scheduling information needed to efficiently execute the commissioning process.

3.5 TESTING, ADJUSTING, AND BALANCING (TAB) CONTRACTOR RESPONSIBILITIES

- 3.5.1 The duties of the TAB contractor are as follows:
 - 3.5.1.1 Six weeks prior to starting TAB, submit to the PM/GC the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead. The Owner will approve the site technician's qualifications for this project.
 - 3.5.1.2 Submit the outline of the TAB plan and approach for each system and component to the CxA, PM/GC and the Controls Contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system. The submitted plan will include:
 - (1) Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
 - (2) An explanation of the intended use of the building control system. The Controls Contractor will comment on feasibility of the plan.
 - (3) All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - (4) Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - (5) Final test report forms to be used.
 - (6) Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow strengtheners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
 - (7) List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.

- (8) Details of how total flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pilot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).
 - (9) The identification and types of measurement instruments to be used and their most recent calibration date.
 - (10) Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
 - (11) Confirmation that TAB understands the outside air ventilation criteria under all conditions.
 - (12) Details of whether and how minimum outside air cfm will be verified and set and for what level (total building, zone, etc.).
 - (13) Details of how building static and exhaust fan / relief damper capacity will be checked.
 - (14) Proposed selection points for sound measurements and sound measurement methods.
 - (15) Details of methods for making any specified coil or other system plant capacity measurements.
 - (16) Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
 - (17) Details regarding specified deferred or seasonal TAB work.
 - (18) Details of any specified false loading of systems to complete TAB work.
 - (19) Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
 - (20) Details of any required interstitial cavity differential pressure measurements and calculations.
 - (21) Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
 - (22) Plan for formal progress reports (scope and frequency).
 - (23) Plan for formal deficiency reports (scope, frequency, and distribution).
- 3.5.1.3 A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CxA and PM/GC at least twice a week.
- 3.5.1.4 Communicate in writing to the Controls Contractor all setpoint and parameter changes made, or problems and discrepancies identified during TAB which affect the control system setup and operation.
- 3.5.1.5 Provide a draft TAB report within two weeks of completion. A copy will be provided to the CxA. The report will contain a full explanation of the methodology, assumptions, and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB.
- 3.5.1.6 Provide the CxA with any requested data, gathered, but not shown on the draft reports.
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- 3.5.1.7 Provide a final TAB report for the CxA with details, as in the draft.
- 3.5.1.8 Conduct functional performance tests and checks on the original TAB as specified for TAB in Section 23 08 00.

3.6 SYSTEM STARTUP

- 3.6.1 The HVAC contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 13, Article "Start-up, Pre-Functional Test Sheets, and Initial Checkout." Division 23 has start-up responsibility and is required to complete systems and sub-systems, so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.
- 3.6.2 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- 3.6.3 Prior to the start up of equipment the Division 23 Contractor shall arrange to have the Manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- 3.6.4 The Supplier shall submit a written report of their findings.
- 3.6.5 Upon confirmation that the equipment has been installed in accordance with the Manufacturers Recommendations the equipment may be started.
- 3.6.6 All equipment shall be started by the Manufacturer's representative.

3.7 PRE-FUNCTIONAL TEST SHEETS

- 3.7.1 Pre-functional test sheets contain items for Division 23 Contractors to perform. On each checklist, a column is provided that is to be completed by the contractor assigning responsibility for that line item to a trade. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- 3.7.2 Refer to Section 01 91 13 for additional requirements regarding pre-functional test sheets, startup, and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CxA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = all Contractors, CxA = Commissioning Authority/Agent, CC = Controls Contractor, EC = Electrical Contractor, PM/GC = General Contractor, MC = Mechanical Contractor, SC = Sheet Metal Contractor, TAB = Test and Balance Contractor.

3.8 TRAINING

- 3.8.1 The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 13 for additional details.
 - 3.8.2 The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01 91 13 for additional details.
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- 3.8.3 Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:
 - 3.8.4 Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 13, Article "Training".
 - 3.8.5 Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, boilers, furnaces, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls, and water treatment systems, etc.
 - 3.8.6 Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
 - 3.8.7 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary, and the demonstration repeated.
 - 3.8.8 The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
 - 3.8.9 The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
 - 3.8.10 The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
 - 3.8.11 Training shall include:
 - 3.8.11.1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - 3.8.11.2 A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - 3.8.11.3 Discussion of relevant health and safety issues and concerns.
 - 3.8.11.4 Discussion of warranties and guarantees.
 - 3.8.11.5 Common troubleshooting problems and solutions.
 - 3.8.11.6 Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
 - 3.8.11.7 Discussion of any peculiarities of equipment installation or operation.
 - 3.8.12 The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1, latest edition is recommended.
 - 3.8.13 Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
 - 3.8.14 Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance for all pieces of equipment.
 - 3.8.15 The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
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- 3.8.16 Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

3.9 DEFERRED TESTING

- 3.9.1 Refer to Section 01 91 13, Article "Deferred Testing" for requirements of deferred testing.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Materials and installation for piping, valves, and fittings for gas fired equipment.

1.2 REFERENCES

- 1.2.1 CSA B149.1:20, Natural Gas and Propane Installation Code.
- 1.2.2 TSSA FS-255-21, Gaseous Fuels Code Adoption Document Amendment: Ontario requirements effective May 1, 2021.
- 1.2.3 CSA C282:19 Emergency Electrical Power.

1.3 DEFINITIONS

- 1.3.1 PRV – Pressure Reducing Valve.

1.4 SUBMITTALS

- 1.4.1 Submit shop drawings/product data for all products specified in Part 2 of this section except for pipe, fittings, and unions. Indicate performance criteria, conformance to appropriate reference standards, and limitations.
- 1.4.2 For each gas pressure regulating station, submit:
 - 1.4.2.1 a selection sheet for each PRV, indicating connected equipment, heating loads, design allowance, meter model, body size, spring range and orifice size;
 - 1.4.2.2 a selection sheet for each relief valve(s) serving a PRV.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Submit maintenance and engineering data for incorporation into manual specified in Section 01 77 00.

1.6 QUALITY ASSURANCE

- 1.6.1 All gas system work is to be in accordance with requirements of CSA B149.1, Natural Gas and Propane Installation Code, as amended by local Gas Codes.
- 1.6.2 All gas system work is to be performed only by licensed gas pipe fitters (holding Gas Technician 1 Certificate) authorized under the TSSA Act.
- 1.6.3 Apply for, on TSSA forms, approval of the gas system design by the TSSA prior to work beginning at the site and prior to ordering any equipment. Submit the completed TSSA form and copies of shop drawings/product data sheets as required to the TSSA and obtain an approval certificate. Pay all costs for the TSSA review and approval process. If the TSSA requires revisions to the system and the revisions result in an extra cost, a Notice of Change will be issued by the Consultant for the revision.

2 PRODUCTS

2.1 PIPE, FITTINGS, AND JOINTS

- 2.1.1 Coated Black Steel - Welded Joints: "Yellow Jacket" Schedule 40 mild black carbon steel, ASTM A53, Grade B, factory coated with yellow plastic, mill or site bevelled, and complete with forged steel butt welding fittings and welded joints. All bare metal surfaces are to be cleaned and corrosion protected with a suitable Denso primer and tape corrosion protection system.
 - 2.1.2 Polyethylene: Safety yellow coloured polyethylene pipe, fittings, and joints to CSA-B137.4.
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- 2.1.3 Coated Copper: Type "K" soft temper copper with a factory applied external yellow plastic coating and flare fittings with forged brass nuts to CAN/CSA-B149.1. Nuts are to be stamped with the designation C37700 to indicate that they are forged brass.
- 2.1.4 Uncoated Black Steel - Screwed Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with malleable cast iron screwed fittings to ANSI B2.1, and screwed joints.
- 2.1.5 Uncoated Black Steel - Welded Joints: Schedule 40 mild black carbon steel, ASTM A53, Grade B, mill or site bevelled, complete with factory made forged steel butt welding fittings and welded joints.
- 2.1.6 Copper-Uncoated: Type "G" seamless copper tubing to ASTM B837, hard temper with wrought copper capillary brazed joint type fittings to ASTM B.61, and brazed joints made with "Sil-Fos" or "Sil-Fos 5" brazing alloy, or, soft temper with flared brass fittings of a single 45° flare type, forged or with a machined long nut and copper to copper threaded connectors, and, where required, flared brass copper to NPS adapters.
- 2.1.7 Flexible Stainless Steel: Flexible, CSA certified, 860 kPa (125 psi) rated, gas-tight, convoluted stainless steel tubing factory jacketed with a bright yellow PVC coating which is continuously identified. The tubing is to be supplied in coils and is to be complete with factory attached stainless steel end fittings, and adapter unions, protective plates, and steel clamps.
 - 2.1.7.1 Manufacturers:
 - (1) Tru-Flex Metal Hose LLC. "Pro-Flex";
 - (2) Titeflex Corp. "Gastite";
 - (3) Omega Flex Canada "TracPipe".

2.2 PIPING UNIONS

- 2.2.1 Screwed Piping: Malleable iron, ground joint, bronze or brass to iron or bronze to bronze seat screwed unions and union elbows with a minimum pressure rating of 1725 kPa (250 psi) steam at 260°C (500°F).
- 2.2.2 Flanged Piping: Forged carbon steel slip-on type raised faced welding flange unions to ASTM A105, 150 lb. Class for steel pipe, and slip-on type 150 lb. Class bronze flanges for copper pipe.
- 2.2.3 Copper to Steel: Equal to Kamco Products "Copper Stopper".

2.3 EARTHQUAKE ACTIVATED AUTOMATIC SHUT-OFF VALVES

- 2.3.1 Equal to KAS International or Nihon Koso Model 315 HPF earthquake activated, flanged, high pressure automatic shut-off valve suitable for both natural gas and propane, ULC listed and in accordance with ANSI Z21.70, Earthquake Actuated Automatic Gas Shutoff Valves.

2.4 SHUT-OFF VALVES

- 2.4.1 Ball Type:
 - 2.4.1.1 CSA certified, minimum 3100 kPa (450 psi) WOG rated, 1/4 turn, full port non-lubricated brass ball valves, each complete with a Teflon PTFE seat, chrome plated solid ball, removable lever handle, and screwed ends.
 - 2.4.1.2 Manufacturers:
 - (1) Neo Valves Inc. #425;
 - (2) Kitz Corp. Code 58;
 - (3) Toyo Valve Co. Fig. 5044A.

- 2.4.2 Plug or Ball Type: CSA certified, plain face flanged, Class 125, 1380 kPa (200 psi) rated, 1/4 turn, cast iron lubricated plug valves, each wrench operated and complete with cylindrical plug with lubricant grooves, lubricant screw, and lubricant receptacle, or full port carbon steel ball valves with flanged ends.

2.4.2.1 Manufacturers:

- (1) Neo Valves Inc. #1AS40114 plug valve;
- (2) Newman Hattersley #171M plug valve;
- (3) Kitz Corp. Code No. 150 SCTAM-FS-CGA ball valve.

2.5 POSITION INDICATING SWITCHES FOR SHUT-OFF VALVES

- 2.5.1 CSA approved limit switch, rated EX db IICT6/EX tb IIIC T85°C explosion proof, class 1, zone 1, IP67 enclosure.
- 2.5.2 Secure water resistant case with multi-angle top and side visual indicator. Red to indicate fully closed position and yellow to indicate fully open position.
- 2.5.3 Two single pole double throw mechanical switches.
- 2.5.4 Includes position indicating contacts for connection of supervisory cabling and remote monitoring of valve status.
- 2.5.5 Manufacturers:
- 2.5.5.1 CVS Controls Ltd., CVS 870 series limit switch.
- 2.5.5.2 Equal by Topworx.

2.6 NATURAL GAS CONVENIENCE OUTLET

- 2.6.1 Neo Valves Model 3/375 quick-connect type CSA certified outlet with interlocking safety cam to prevent release of the appliance connector until the valve is off, integral thermal protection to prevent gas flow if the outlet is exposed to temperatures exceeding 90°C (195°F), and a wall enclosure box.
- 2.6.2 Manufacturers:
- 2.6.2.1 Neo Valves Inc.;
- 2.6.2.2 Fairview Fittings & Mfg. Ltd.

2.7 PRESSURE REGULATORS

- 2.7.1 CSA certified pressure regulators as follows:
- 2.7.1.1 non-vented type: lever action, dead end lockup type, each complete with a vent limiter, self-aligning valve, die-cast aluminium housing, and synthetic rubber compound diaphragm;
- 2.7.1.2 vented type: spring-loaded self-operated design, tight closing, selected for the facility gas pressure and piping pressure loss, and connected equipment load at full firing rate plus 20% spare, and complete with:
- (1) 1035 kPa (150 psi) rated cast iron body finished with corrosive resistant epoxy enamel;
 - (2) aluminum diaphragm and spring case with Nitrile diaphragm, disc, and body o-ring;
 - (3) throttling type, high flow rate, tight shut-off relief valve selected to protect equipment downstream of the regulator in coordination with regulator capacity.
- 2.7.2 Manufacturers:
- 2.7.2.1 Maxitrol Co.;
- 2.7.2.2 Fisher Controls;
- 2.7.2.3 Leslie Controls Inc.;

2.7.2.4 Lakeside Process Controls.

2.8 GAS METER

- 2.8.1 In accordance with Enbridge requirements.
- 2.8.2 Connect gas meter pulse output to metering equipment noted on the electrical drawings.

3 EXECUTION

3.1 NATURAL GAS SERVICE

- 3.1.1 Make all required arrangement with the natural gas supply utility on behalf of the Owner for installation of natural gas service piping with gas pressure regulator and meter assembly.
- 3.1.2 Provide an earthquake activated automatic shut-off valve in gas service piping outside the building in accordance with the valve manufacturer's installation instructions. Provide an angle iron framed wire mesh enclosure around the valve and bolted to the wall.
- 3.1.3 Provide 2 m (7') high minimum 200 mm (8") diameter Schedule 80 galvanized steel concrete filled bollards at the meter-regulator location in a pattern to protect the meter-regulator. Install the pipe straight and plumb a 1.2 m (4') below grade in a continuous 600 mm (2') diameter reinforced concrete footing. Smoothly crown the top of the concrete above the top of the pipe.

3.2 NATURAL GAS PIPING INSTALLATION REQUIREMENTS

- 3.2.1 Provide all required natural gas distribution piping and connect gas fired or operated equipment, and provide all required vent piping to atmosphere, including vent piping from pressure regulators. Do all piping work in accordance with requirements of CAN/CSA-B149.1, Natural Gas and Propane Installation Code, as amended by local Gas Codes.
 - 3.2.2 Piping is to be as follows:
 - 3.2.2.1 for underground piping, coated Schedule 40 black steel, coated soft copper, or polyethylene;
 - 3.2.2.2 for above ground piping, uncoated Schedule 40 black steel, hard temper or soft copper, or, if permitted, flexible stainless steel.
 - 3.2.3 Install flexible stainless steel pipe in strict accordance with the pipe manufacturer's printed instructions.
 - 3.2.4 Slope gas piping in the direction of flow to low points.
 - 3.2.5 Where natural gas piping is run vertically through internal building risers, provide vent through roof for reach riser.
 - 3.2.6 Where natural piping serving an emergency generator is run internally to the building, provide a fire rated enclosure around that piping, isolated from all other natural gas piping or other building services.
 - 3.2.7 Ensure that supports for roof mounted piping are sized (height) to accommodate the roof slope and the required piping slope, and to permit the installation of low point dirt pockets.
 - 3.2.8 Provide full pipe diameter 150 mm (6") long drip pockets at the bottom of all vertical risers, at all piping low points, and wherever else shown and/or required.
 - 3.2.9 Identify all natural gas piping above ground with two coats of safety yellow enamel applied over primer and coil type vinyl identification makers with arrows. SMS Ltd. or equal can be used for identification markers.
 - 3.2.10 For all underground gas piping, provide continuous 75 mm (3") wide yellow PVC warning tape with "CAUTION - GAS LINE BURIED BELOW" wording at 750 mm (30") intervals located above the pipe approximately 250 mm (10") below grade.
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- 3.2.11 Rough-in all required natural gas piping for kitchen and laundry equipment in accordance with drawing plans and schedules. Obtain accurately dimensioned rough-in drawings for the equipment and confirm exact locations prior to roughing-in. When the equipment has been installed, connect the equipment from the roughed-in Work. Provide shut-off valves in all piping connections to the equipment.
- 3.2.12 Include for mounting only of a solenoid valve in the gas piping to kitchen cooking equipment.

3.3 *INSTALLATION OF SHUT-OFF VALVES*

- 3.3.1 Provide CSA approved ball type or lubricated plug type shut-off valves to isolate equipment, and wherever else shown.
- 3.3.2 Ensure that valves are located for easy accessibility and maintenance.
- 3.3.3 For all valves installed in an emergency gas supply line including, but not limited to, the regulator station. Provide position indicating contacts to initiate a trouble alarm condition at the generator control panel and/or fire alarm control panel when any valve is closed. Provide in accordance with CSA C282:19 Emergency Electrical Power. Coordinate with electrical trade and generator supplier.

3.4 *INSTALLATION OF NATURAL GAS CONVENIENCE OUTLETS*

- 3.4.1 Provide natural gas convenience outlets and wall mount.
- 3.4.2 Provide a shut-off valve in connecting piping, confirm exact location prior to roughing-in, and ensure that the outlet is rigidly secured in place.

3.5 *INSTALLATION OF PRESSURE REGULATORS*

- 3.5.1 Provide pressure regulators in gas distribution piping where indicated and/or required.
- 3.5.2 For indoor appliances, use lever acting design vent limiter type, sized as shown and mounted in a horizontal upright position in strict accordance with the manufacturer's instructions. Note that these pressure regulators do not require vent piping.
- 3.5.3 Use vented type pressure regulators for all other applications.
- 3.5.4 Install regulating stations in accordance with requirements of CAN/CSA-B149.1.
- 3.5.5 Provide a manual shut-off valve upstream of the pressure regulator and provide overpressure protection devices.
- 3.5.6 Provide 6 mm (1/4") diameter test ports upstream and downstream of each regulator assembly.
- 3.5.7 Locate outdoor regulating stations vent termination a minimum of 300 mm (12") away from walkways, and 3 m (10') away from equipment air intakes and building openings. Provide all required vent piping and terminate vents in a turn-down elbow fitting with bronze bug screen secured in place.
- 3.5.8 Locate indoor regulating stations in locations accessible without the use of ladders or lifts. Combine vents where permitted and increase vent pipe size accordingly. Extend vent piping up through the roof 3 m (10') away from equipment air intakes and building openings and terminated in a turn-down elbow fitting with bronze bug screen secured in place.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for all products specified in this section except piping and unions.
- 1.1.2 Submit motor product data sheets and certified performance curves with all pump shop drawings.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit with delivery of each unit a copy of factory inspection and test report, and include a copy of each report with O&M Manual project closeout data.
- 1.2.2 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this section.
- 1.2.3 Prior to Substantial Performance of the Work, submit a spare seal flush line filter for each pump equipped with a seal flush line.
- 1.2.4 Shop drawings for piping anchors must be prepared and stamped by a professional Structural Engineer registered in the jurisdiction of the work. Refer to requirements for Contractor retained engineers specified in Section 20 05 10 – Mechanical Work General Instructions.
- 1.2.5 Submit a letter from pipe anchor design engineer to stating engineer has visited site to examine installation of pipe anchors and pipe anchor installation is in accordance with reviewed anchor shop drawing.

1.3 QUALITY ASSURANCE

- 1.3.1 Pump motors are to comply with requirements of Section 20 05 00 – Common Work Results for Mechanical.

2 PRODUCTS

2.1 PIPE, FITTINGS, AND JOINTS

- 2.1.1 Black Steel - Screwed Joint
 - 2.1.1.1 Mild black carbon steel, Grade B, ASTM A53, complete with Class 125 cast iron threaded fittings to ANSI/ASME B16.4, and screwed joints.
- 2.1.2 Black Steel - Welded Joint
 - 2.1.2.1 Mild black carbon steel, Grade B, ASTM A53, mill or site bevelled, complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, with long sweep pattern elbows unless otherwise specified, and welded joints.
- 2.1.3 Black Steel - Grooved End Mechanical Joint
 - 2.1.3.1 Mild black carbon steel, Grade B, ASTM A53, factory or site roll grooved, complete with cast ductile iron grooved end fittings, including full flow elbows, and conforming to ASTM A536.
 - 2.1.3.2 Manufacturers:
 - (1) Equal to Victaulic Style 107 "QuickVic" rigid couplings for sizes 2" to 12", Style 07 "Zero-Flex" rigid couplings, Style W07 AGS rigid couplings for sizes 350 mm (14") to 1525 mm (60");
 - (2) Flexible grooved couplings can be used where system flexibility is desired. Noise and vibration reduction at mechanical equipment connections is achieved by installing three flexible couplings near the vibrations source in lieu of braided flex connectors. Victaulic Style 177 QuickVic or Style 77

flexible couplings for sizes 50 mm (2") to 300 mm (12"). Style W77 AGS flexible couplings for sizes 350 mm (14") to 1525 mm (60").

- (3) Grooved end fittings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12, forged steel conforming to ASTM A-234, Grade WPB 0.375" wall (9.53 mm wall), or fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A-53, Type F, E or S, Grade B. Fittings provided with an alkyd enamel finish or hot dip galvanized to ASTM A-153. Branch reductions on 2" (DN50) through 8" (DN200) header piping. Bolted branch outlets shall be manufactured from ductile iron conforming to ASTM A-536, Grade 65-45-12, with synthetic rubber gasket, and heat treated carbon steel zinc plated bolts and nuts conforming to physical properties of ASTM A-183. Victaulic Style 920 / 920N.
- 2.1.4 Black Steel – Plain End Mechanical Joint
 - 2.1.4.1 Mild black carbon steel, Grade B, ASTM A53, mill or site bevelled, complete with cast ductile iron end fittings conforming to ASTM A536.
 - 2.1.4.2 Manufacturers:
 - (1) Equal to Victaulic QuickVic SD rigid couplings for sizes 1/2" to 2", rated for a working pressure of 300 psi.
- 2.1.5 Black Steel – Pressure Coupled Joints
 - 2.1.5.1 Mild black carbon steel conforming to ASTM F3226, IAPMO PS117, ICC LC1002, ASME B31.1, B31.3, or B31.9. MegaPress fittings ½-inch thru 4-inch for use with schedule 40 ASTM A53 carbon steel pipe.
 - 2.1.5.2 Pressure connect fittings shall carry CRN numbers.
 - 2.1.5.3 Pressure connect fitting shall have Viega Smart Connect technology to detect unpressed fittings shall be integrated into the body of the fitting.
 - 2.1.5.4 1/2 inch thru 2 inch fittings shall have stainless-steel grip ring with bidirectional teeth, 304 stainless separator ring, EPDM or FKM sealing element at each press connection. 2-1/2 inch thru 4 inch shall have stainless-steel grip ring with bidirectional teeth, PBT separator ring, and FKM sealing element at each press connection.
 - 2.1.5.5 There shall be no mixing of manufacturers.
 - 2.1.5.6 The manufacturer's installation instructions shall be strictly adhered to.
 - 2.1.5.7 Special attention shall be given to the required two step pressure test.
 - 2.1.5.8 Initial test for unpressed fitting detection per manufacturer's installation manual.
 - 2.1.5.9 Full pressure test in accordance with code requirements.
 - 2.1.5.10 Installers shall be field trained by Viega factory representative.
- 2.1.6 Soft Copper Pipe
 - 2.1.6.1 Type "L" seamless soft copper to ASTM B77.
- 2.1.7 Hard Copper - Solder Joint
 - 2.1.7.1 Type "L" hard drawn seamless copper to ASTM B88, complete with wrought copper fittings to ANSI B16.22, and 95% tin / 5% Antimony solder joints.
- 2.1.8 Hard Copper - Pressure Coupled Joint
 - 2.1.8.1 Type "L" hard drawn seamless copper to ASTM B88, complete with Viega "ProPress with Smart Connect feature" system copper fittings with EDPM seals, and pressure type crimped joints made by use of manufacturer recommended tool.

2.2 PIPING UNIONS

- 2.2.1 Screwed Piping
 - 2.2.1.1 Malleable iron, ground joint, bronze or brass to iron or bronze to bronze seat screwed unions and union elbows with a minimum pressure rating of 1725 kPa (250 psi) steam at 260°C (500°F).

2.2.2 Flanged Piping

- 2.2.2.1 Forged carbon steel slip-on type raised faced welding flange unions to ASTM A105, 150 lb. Class for steel pipe, and slip-on type 150 lb. Class bronze flanges for copper pipe.

2.3 SHUT-OFF VALVES

2.3.1 Ball Type

- 2.3.1.1 Class 600, 4140 kPa (600 psi) WOG rated full port ball valves, each complete with a forged brass or bronze body and cap, blowout-proof stem, solid forged brass chrome plated ball, "Teflon" or "PTFE" seat, threaded ends, and removable lever handle.

2.3.1.2 Manufacturers:

- (1) Toyo Valve Co. Fig. 5044A;
- (2) Watts Industries (Canada) Inc. #FBV-3;
- (3) Kitz Corp. Code 58;
- (4) Victaulic Co. of Canada Ltd. Series 722;
- (5) Apollo Valve #77-100.

2.3.2 Butterfly Type

- 2.3.2.1 Cast ductile iron, lug body style, 1200 kPa (175 psi) rated butterfly valve, each complete with a neck to permit 50 mm (2") of insulation above the flange, a field replaceable EPDM seat, ductile iron disc, stainless steel shaft with EPDM seal, a lever handle for valves to and including 150 mm (6") diameter, a handwheel and gear type operator for valves larger than 150 mm (6") diameter, and each suitable for bubble-tight dead end service with valve closed and either side of connecting piping removed.

2.3.2.2 Manufacturers:

- (1) DeZurik of Canada Ltd., Figure No. 632;
- (2) Victaulic Co. of Canada Ltd. Vic-300 MasterSeal or AGS Vic-300;
- (3) Apollo Valve 143 Series;
- (4) Watts Industries (Canada) Inc. #BF-03;
- (5) Kitz Corp. 6112 Series;
- (6) Toyo Valve Co. 918DESL/G2.

2.4 SWING CHECK VALVES

2.4.1 Bronze - Screwed

- 2.4.1.1 Class 125, 1380 kPa (200 psi) WOG rated horizontal swing check valves, each complete with a "Y" pattern bronze body, hinged brass disc, easy access screw-in cap, and screwed ends.

2.4.1.2 Manufacturers:

- (1) Toyo Valve Co. Fig. 236;
- (2) Nibco #T-433;
- (3) Kitz Corp. Code No. 22.

2.4.2 Steel - Grooved Ends

- 2.4.2.1 Victaulic Co. of Canada Ltd. Series 716, 779 or W715 grooved end carbon steel check valves suitable for mounting horizontally or vertically.

2.4.3 Cast Iron - Screwed and Flanged

- 2.4.3.1 Cast iron, bronze trim, 1380 kPa (200 psi) rated swing check valves, each complete with a bronze disc and seat, malleable iron hinge, bolted cover, and screwed or flanged ends as required.
- 2.4.3.2 Manufacturers:
 - (1) Toyo Valve Co. Fig. 435A;
 - (2) Watts Industries (Canada) Inc. #F-511;
 - (3) Kitz Corp. Code No. 78.

2.5 VERTICAL LIFT CHECK VALVES

- 2.5.1 Class 150, 1380 kPa (200 psi) WOG rated bronze vertical lift check valves, each complete with screwed ends and a bronze disc.
- 2.5.2 Manufacturers:
 - 2.5.2.1 Toyo Valve Co. Fig. 231;
 - 2.5.2.2 Watts Industries (Canada) Inc. #600;
 - 2.5.2.3 Kitz Corp. Code No. 36.

2.6 WAFER CHECK VALVES

- 2.6.1 Threaded lug body type, full bore, ANSI Series 150, 1965 kPa (285 psi) rated at 38°C (100°F), non-slam wafer check valves, each complete with a carbon steel body, stainless steel discs, a shaft, springs, disc stop and thrust bearings constructed of type 316 stainless steel, and seat materials to suit the application. The inside diameter of the valve must equal the inside diameter of the connecting pipe.
- 2.6.2 Manufacturers:
 - 2.6.2.1 Gulf Valve Co. "WAFER CHECK";
 - 2.6.2.2 Watts Industries (Canada) Inc. Series ICV-125;
 - 2.6.2.3 The Metraflex Co. Style CVXX.

2.7 DRAIN VALVES

- 2.7.1 Minimum 2070 kPa (300 psi) WOG rated, 20 mm (¾") diameter straight pattern bronze ball valves, each complete with a threaded outlet suitable for coupling connection of 20 mm (¾") diameter hose, and a cap and chain.
- 2.7.2 Manufacturers:
 - 2.7.2.1 Toyo Valve Co. Ltd. Fig. 5046;
 - 2.7.2.2 Watts Industries (Canada) Inc. #B-6000-CC;
 - 2.7.2.3 Kitz Corp. Code No. 68AC;
 - 2.7.2.4 Apollo Valves #78-104-01.

2.8 CIRCUIT BALANCING VALVES

- 2.8.1 Screwed or flanged as required, globe style, non-ferrous circuit balancing valves designed to facilitate precise flow measurement, precision flow balancing, and positive shut-off, complete with capped and valved drain connection, and valved ports for connection to a differential pressure meter.
- 2.8.2 Manufacturers:
 - 2.8.2.1 Equal to Victaulic Co. of Canada Ltd. (Tour & Anderson) Series 787 screwed, Series 788 flanged, and 789 grooved end, and Series 78K "Koil Kit" valves.

2.9 RADIATOR SHUT-OFF AND BALANCING VALVES

- 2.9.1 Heavy pattern, straight, 1750 kPa (250 psi) rated at 120°C (250°F) bronze radiator valves, each complete with composition disc, spring loaded packing, and union. Equip inlet valves with a handle for shut-off. Equip outlet valves with a lockshield for shut-off and balancing.
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- 2.9.2 Manufacturers:
 - 2.9.2.1 Dahl Brothers Canada Ltd. #11042 and #13013;
 - 2.9.2.2 Spirax Sarco Ltd. Type R.

2.10 PRESSURE RELIEF VALVES

- 2.10.1 ASME tested, rated, and certified, bronze or cast iron bronze fitted, 1725 kPa (250 psi) rated pressure relief valves, each capable of relieving full output of equipment it is associated with, and each factory set at 415 kPa (60 psi) unless otherwise specified.
- 2.10.2 Manufacturers:
 - 2.10.2.1 ITT Bell & Gossett 3301/4100, or 790/1170;
 - 2.10.2.2 Dresser Industries "CONSOLIDATED";
 - 2.10.2.3 Spirax Sarco Ltd. SVI Series;
 - 2.10.2.4 McDonnell & Miller Models 250 and 260;
 - 2.10.2.5 Conbraco 10-600 Series;
 - 2.10.2.6 Watts Industries (Canada) Inc. 174A or 740.

2.11 AIR VENTS

- 2.11.1 Manual Air Vents
 - 2.11.1.1 Equal to Conbraco 27 Series, 3.2 mm ($\frac{1}{8}$ ") diameter with a key handle.
- 2.11.2 Automatic Air Vents
 - 2.11.2.1 Float actuated air vents, each complete with a semi-steel body and cap, a stainless steel float assembly and seat, and a neoprene head.
 - 2.11.2.2 Manufacturers:
 - (1) Spirax Sarco Ltd., Type 13 W for system working pressures to 1035 kPa (150 psi), 13 WH for system working pressures greater than 1035 kPa (150 psi);
 - (2) Armstrong International Inc. No. 1-AV.

2.12 STRAINERS

- 2.12.1 Cast iron wye shaped strainers, minimum 890 kPa (125 psi) rated and complete with a removable type 304 stainless steel screen with perforations sized to suit the application, and, for strainers 50 mm (2") diameter and larger, a blowdown pipe connection tapping.
- 2.12.2 Manufacturers:
 - 2.12.2.1 Spirax Sarco Ltd. Type IF-125 screwed or Type AF-250 flanged;
 - 2.12.2.2 Toyo Valve Co. Ltd. Fig. 380A screwed or Fig. 381 flanged;
 - 2.12.2.3 Victaulic Co. of Canada Style 732 or W732 "Vic-Strainer";
 - 2.12.2.4 Armstrong International Inc. A1 Series;
 - 2.12.2.5 Watts Industries (Canada) Inc. #77SCI;
 - 2.12.2.6 Mueller Steam Specialty Products Model 11M screwed or Model 758 flanged.

2.13 PIPING EXPANSION JOINTS

- 2.13.1 Steel Piping Mains:
 - 2.13.1.1 Controlled flexing, flanged expansion joints, 2070 kPa (300 psi) rated, with corrugated stainless steel bellows with closely matched neck rings and reinforcing or control rings, and selected for operating pressure plus 25% safety factor.
 - 2.13.1.2 Manufacturers:
 - (1) Senior Flexonics Ltd. Series CSF "High-Corr";
 - (2) Victaulic Co. of Canada Ltd. Style 155 with Style 07 or 107 "Zero-Flex" couplings on each side of assembly and a full length steel "V" shaped support trough with hangers;

(3) The Metraflex Co. Model MC.

2.13.2 Steel or Copper Branch/Runout Piping:

2.13.2.1 Externally pressurized, 1380 kPa (200 psi) rated expansion joints with a stainless steel bellows and shroud, welding or threaded steel nipple ends for steel piping, and copper sweat nipple ends for copper piping.

2.13.2.2 Manufacturers:

(1) Senior Flexonics Ltd. Series "H";

(2) The Metraflex Co. Model "HP".

2.14 PIPING ALIGNMENT GUIDES

2.14.1 Prime coat painted black carbon steel pipe alignment guides sized and fabricated to suit pipe size and pipe insulation thickness.

2.14.2 Manufacturers:

2.14.2.1 Senior Flexonics Ltd. Series PGT;

2.14.2.2 E. Myatt & Co. Ltd. Fig. 1267;

2.14.2.3 Empire Tool & Mfg. Inc. Fig 256;

2.14.2.4 The Metraflex Co. Style IV.

2.15 PIPE ANCHORS

2.15.1 Welded structural black steel anchors of a design, size, and type to securely anchor pipe at point shown. Each anchor is to withstand 150% of axial thrust, and, as specified in Part 1 of this section, is to be designed and detailed by a Professional Structural Engineer.

2.16 FLEXIBLE PUMP CONNECTIONS

2.16.1 Flexible metal hose assemblies, each complete with annular corrugated unbraided type 321 stainless steel inner core, braided type 321 stainless steel hose, and a collar and flange at each end, all suitable for twice the working pressure of the system.

2.16.2 Manufacturers:

2.16.2.1 Senior Flexonics Inc. A1 and A6 Series;

2.16.2.2 The Metraflex Co. Model SST and "METRA-MINI".

2.16.3 Option: Victaulic Series 380, 381 or 382 pump drop assemblies. Includes flow control, vibration-controlling flexible couplings, access ports for gauges and thermowells and an integral flanged pump connection. Rated to the working pressure of Class 150 flange connection. Sizes 2" to 12".

2.17 AIR SEPARATORS

2.17.1 Vortex type vertical air separator with side tangential inlet and outlet connections, a top air outlet connection, and bottom drain connection. Separator is to be constructed of cast iron or fabricated steel for a pressure of 1105 kPa (160 psi) at 180°C (350°F) in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.

2.17.2 Manufacturers:

2.17.2.1 S.A. Armstrong Ltd. Model "VA".

2.17.2.2 ITT Bell & Gossett "Rolairtrol".

2.17.2.3 Taco Canada Ltd. "Vortech".

2.17.2.4 Flo-Fab Inc. "SEP-T" Series.

2.18 EXPANSION TANKS

2.18.1 Replaceable bladder type, factory pressurized expansion tank with permanent separation of air and water, in accordance with drawing schedule and complete with:

- 2.18.1.1 steel pressure tank suitable for a working pressure of 870 kPa (125 psi) at 115°C (240°F), constructed and stamped in accordance with the ASME Code for Unfired Pressure Vessels and complete with a system connection, drain connection, air charging valve, and a red oxide primer finish;
- 2.18.1.2 heavy-duty butyl rubber (EDPM) bladder;
- 2.18.1.3 tapping for installation of a pressure gauge;
- 2.18.1.4 For horizontal tanks only, mounting saddles supplied loose;
- 2.18.1.5 factory secured seismic restraint connection hardware.
- 2.18.2 Manufacturers:
 - 2.18.2.1 Hamlet & Garneau Inc. AL Series "Expanflex";
 - 2.18.2.2 S.A. Armstrong Ltd. Series "AX-V" Series "L";
 - 2.18.2.3 ITT Bell & Gossett Series "B" (ASME);
 - 2.18.2.4 Amtrol "Extrol" Series.
 - 2.18.2.5 Taco (Canada) Ltd. "CBX" Series.
 - 2.18.2.6 Flo-Fab Inc. "WX-C" Series, "ABT" Series

2.19 GLYCOL SOLUTION MIXING AND STORAGE TANKS

- 2.19.1 Package type glycol solution mixing, storage and automatic feed assembly designed to maintain minimum system pressure levels and complete with:
 - 2.19.1.1 round, polyethylene or polypropylene tank sized to suit system capacity, complete with a solution level scale in litres and Imperial gallons, removable cover, and a welded steel angle stand assembly with legs, pump shelf, and control panel bracket, all factory finished with enamel;
 - 2.19.1.2 factory pre-piped minimum 1/3 hp, 115 volt, 1-phase rotary bronze gear pump with capacity and pressure differential to suit system requirements, factory wired to control panel, mounted on a shelf integral with steel stand assembly, and complete with shut-off valve and strainer;
 - 2.19.1.3 tank pressure relief valve with discharge piped back into tank;
 - 2.19.1.4 tank low level switch;
 - 2.19.1.5 pressure gauge;
 - 2.19.1.6 Honeywell #L404A "Pressurtrol" or equal pipe mounting differential pressure switch with a 100 kPa to 1000 kPa (15 psi to 150 psi) range;
 - 2.19.1.7 115 volt, 1-phase, factory mounted and pre-wired control panel with an NEMA 2 enamelled steel enclosure, designed to control and operate glycol gear pump either manually or automatically to pump glycol solution into system, and to stop pump and initiate an audible/visual alarm if a low glycol solution level occurs in tank, and complete with:
 - (1) terminal blocks for power and control wiring connections;
 - (2) H-O-A switch with green "Power On" indicator light;
 - (3) 120 volt/12 volt control transformer;
 - (4) low glycol solution level alarm buzzer with silencing switch, an alarm light which remains illuminated until low-level switch is reset, and an alarm push-to-test button;
 - (5) dry contacts for building automation system alarm annunciation.
 - 2.19.1.8 factory secured seismic restraint connection hardware.
 - 2.19.2 Manufacturers:
 - 2.19.2.1 ITT Bell & Gossett Series GMU;
 - 2.19.2.2 S. A. Armstrong Ltd. GLA Standard Series;
 - 2.19.2.3 HG Spec. Inc.
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2.20 GLYCOL

- 2.20.1 Propylene glycol blended with Nitrite based corrosion inhibitors.

2.21 GENERAL RE: CIRCULATING PUMPS

- 2.21.1 Pumps are to be bronze fitted centrifugal pumps in accordance with drawing schedule, each non-overloading under all operating conditions and factory tested at specified operating conditions.

2.22 BASE MOUNTED PUMPS

- 2.22.1 End suction, horizontal, top discharge, factory mounted and aligned on a steel baseplate, connected to a motor by means of a flexible coupling with guard, and complete with:
- 2.22.1.1 heavy-duty, radially split, gasketed cast iron volute designed for servicing and removal of rotating assembly without disturbing pipe connections, and complete with plugged tappings for gauge and drain;
 - 2.22.1.2 balanced bronze impeller secured to a carbon steel shaft equipped with a stainless steel shaft sleeve;
 - 2.22.1.3 ball type, heavy-duty, lifetime lubricated sealed bearings with back pull-out design bearing frame;
 - 2.22.1.4 TEFC motor;
 - 2.22.1.5 watertight John Crane Inc. JC2, OPID1 carbon rotating face type mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure the stationary seat.
- 2.22.2 Manufacturers:
- 2.22.2.1 S.A. Armstrong Ltd.;
 - 2.22.2.2 ITT Bell & Gossett;
 - 2.22.2.3 Grundfos CBS Inc. PACO;
 - 2.22.2.4 Patterson Pump Company.

2.23 SPLIT COUPLED VERTICAL IN-LINE PUMP

- 2.23.1 Split coupled, single stage, vertical in-line pump complete with:
- 2.23.1.1 radially split, gasketed cast iron volute with equally sized suction and discharge flanged connections, tappings for gauge, drain and flush line connections, and a cast iron motor mount bracket;
 - 2.23.1.2 dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;
 - 2.23.1.3 TEFC vertical mount motor;
 - 2.23.1.4 watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat;
 - 2.23.1.5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
 - 2.23.1.6 For pump(s), in lieu of a flush line filter, factory installed valved seal flush line tubing with cyclone type separator and sight flow indicator.
- 2.23.2 Manufacturers:
- 2.23.2.1 S.A. Armstrong Ltd.;
 - 2.23.2.2 ITT Bell & Gossett;
 - 2.23.2.3 Grundfos CBS Inc. PACO;
-

2.23.2.4 Patterson Pump Company.

2.24 CLOSE COUPLED VERTICAL IN-LINE PUMP

- 2.24.1 Close coupled, single stage vertical in-line pump complete with:
 - 2.24.1.1 radially split, gasketed cast iron volute with equally sized suction and discharge flanged connections, and tapings for gauge, drain and flush line connections;
 - 2.24.1.2 dynamically balanced bronze impeller with bronze shaft sleeve, secured to motor shaft;
 - 2.24.1.3 face mounted TEFC vertical motor;
 - 2.24.1.4 watertight John Crane Inc. #JC 8B2, XP1D1 or Durmetallic #RA EU5-FV carbon rotating face type inside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat.
- 2.24.2 Manufacturers:
 - 2.24.2.1 S.A. Armstrong Ltd.;
 - 2.24.2.2 ITT Bell & Gossett;
 - 2.24.2.3 Grunfos CBS Inc. PACO;
 - 2.24.2.4 Patterson Pump Company.

2.25 SPLIT COUPLED, DUAL VERTICAL IN-LINE PUMP

- 2.25.1 Split coupled, single stage, vertical in-line pump assemblies incorporating 2 radially split pumps, complete with:
 - 2.25.1.1 cast iron volute with equally sized suction and discharge flanged connections, tapings for gauge, drain and flush line connections, and cast iron motor mount brackets;
 - 2.25.1.2 For each pump, dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;
 - 2.25.1.3 For each pump, a TEFC vertical mount motor;
 - 2.25.1.4 For each pump, a watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure the stationary seat;
 - 2.25.1.5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
- 2.25.2 Manufacturers:
 - 2.25.2.1 S. A. Armstrong Ltd.;
 - 2.25.2.2 ITT Bell & Gossett;
 - 2.25.2.3 Grunfos CBS Inc. PACO.

2.26 SPLIT COUPLED, DUAL, VFD DRIVE VERTICAL IN-LINE PUMP

- 2.26.1 Split coupled, single stage, vertical in-line pump assemblies incorporating 2 radially split pumps, complete with:
 - 2.26.1.1 cast iron volute with equally sized suction and discharge flanged connections, tapings for gauge, drain and flush line connections, and cast iron motor mount brackets;
 - 2.26.1.2 For each pump, a dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;

- 2.26.1.3 For each pump, a TEFC vertical mount motor;
- 2.26.1.4 For each pump, a watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat;
- 2.26.1.5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
- 2.26.1.6 For each pump, a factory mounted VFD pre-wired to pump motor, capable of operating in any of following control modes:
 - (1) duty/standby pumps with sensorless control;
 - (2) duty/standby pumps with remote sensor or building automation system control;
 - (3) parallel pumps with single or multiple sensor(s) system control with IPS controller.
- 2.26.1.7 For pump(s), in lieu of a flush line filter, factory installed valved seal flush line tubing with cyclone type separator and sight flow indicator.
- 2.26.2 Manufacturers:
 - 2.26.2.1 S. A. Armstrong Ltd.;
 - 2.26.2.2 ITT Bell & Gossett;
 - 2.26.2.3 Grundfos CBS Inc. PACO.

2.27 CLOSE COUPLED, DUAL VERTICAL IN-LINE PUMP

- 2.27.1 Close coupled, single stage, vertical in-line pump assemblies incorporating 2 radially split pumps, complete with:
 - 2.27.1.1 cast iron volute with equally sized suction and discharge flanged connections, tappings for gauge, drain and flush line connections, and cast iron motor mount brackets;
 - 2.27.1.2 For each pump, a dynamically balanced cast bronze impeller secured to a type 416 stainless steel shaft which is connected to motor by means of a high tensile strength aluminium bar split type spacer coupling with guard designed to permit servicing of mechanical seal without disturbing pump, motor, or electrical wiring;
 - 2.27.1.3 For each pump, a TEFC vertical mount motor;
 - 2.27.1.4 For each pump, a watertight John Crane Inc. #JC8B2, XP1D1 or Durametallic #RA EU5-FV carbon rotating face type outside mechanical seal with tungsten carbide stationary seat, Viton secondary seal and alloy 20 springs, and bronze gland plate with stainless steel gland bolts to secure stationary seat;
 - 2.27.1.5 factory installed seal flush line tubing with 50 micron Cuno cartridge type filter with 2 extra cartridges, a sight flow indicator, air vent, and valved tubing;
 - 2.27.1.6 For pump(s), in lieu of a flush line filter, factory installed valved seal flush line tubing with cyclone type separator and sight flow indicator.

2.28 VERTICAL IN-LINE PUMP VARIABLE FREQUENCY DRIVES

- 2.28.1 Variable frequency drives for vertical in-line pumps as scheduled are to be in accordance with Section 20 05 13.13 – Variable Frequency Drives for Mechanical Equipment.

2.29 CIRCULATING PUMP SUCTION AND DISCHARGE CONNECTION ACCESSORIES

- 2.29.1 Circulating pump manufacturer supplied suction guides with a cast iron body, stainless steel strainer screen, removable fine mesh start-up strainer screen and steel guide vanes, and cast iron body, angle, or straight type control valve assemblies, each acting as a check valve, balancing valve, and shut-off valve. Unless otherwise shown or specified, suction and discharge connection accessories are to be piping line size.
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2.29.2 Manufacturers:

- 2.29.2.1 S.A. Armstrong Ltd. Type "SG" suction guides and "Flo-Trex" triple duty valve assemblies;
- 2.29.2.2 ITT Bell & Gossett Bulletin B-820D suction guides and Bulletin B-821F triple duty valve assemblies.

2.30 HORIZONTAL IN-LINE PUMP

2.30.1 Horizontal, in-line pump complete with:

- 2.30.1.1 cast iron casing with flanged in-line pipe connections;
- 2.30.1.2 alloy steel shaft with integral thrust collar, copper shaft sleeve, and oil lubricated bronze bearings;
- 2.30.1.3 balanced, corrosion resistant steel, cast bronze, or stamped brass impeller;
- 2.30.1.4 motor connected to pump by means of a 4-spring coupling with guard;
- 2.30.1.5 mechanical seal.

2.30.2 Manufacturers:

- 2.30.2.1 S.A. Armstrong Ltd.;
- 2.30.2.2 ITT Bell & Gossett;
- 2.30.2.3 Grundfos Canada Inc.

2.31 WET ROTOR 3-SPEED HORIZONTAL IN-LINE PUMP

2.31.1 Grundfos Canada Inc. "VersFlo" Series UPS wet rotor design, 3-speed horizontal in-line pump with a head-capacity curve that has a steady rise in head from maximum to minimum flow within preferred operating range, factory tested as an assembly and with a maximum noise level when operating of 41 dBA, capable of continuous operation at 120°C (248°F), and equipped with:

- 2.31.1.1 cast iron housing with flanged inlet and outlet with gauge taps, laser welded stainless steel impeller, bearing plate and shaft, stainless steel neck ring, dynamically balanced rotor with stainless steel cladding, and tungsten carbide sleeve type motor bearings;
- 2.31.1.2 3-speed asynchronous, squirrel cage, self-venting motor cooled by pumped fluid and complete with stator housing drain holes to permit condensed water to drain;
- 2.31.1.3 bolt-on terminal box with 3-speed switch assembly with each speed having a distinct pump performance curve, and fibre optic indicator lights for visual inspection of on/off, rotation, and troubleshooting;
- 2.31.1.4 terminal box add-on protective module to permit direct electrical connection to feeder switch;
- 2.31.1.5 terminal box add-on relay module to permit direct connection to electrical feeder switch, signals output for external operating or fault indications, and to permit operation of 2 pumps in parallel with 24 hour alternation;

2.31.2 Manufacturers:

- 2.31.2.1 Grundfos Canada Inc.;
- 2.31.2.2 S. A. Armstrong Ltd.

2.32 WET ROTOR VARIABLE SPEED HORIZONTAL IN-LINE PUMP

2.32.1 Grundfos Canada Inc. "Magna" Series wet rotor design, horizontal, variable frequency drive in-line pump with a head-capacity curve that has a steady rise in head from maximum to minimum flow within preferred operating range, factory tested as an assembly and with a maximum noise level when operating of 41 dBA, capable of continuous operation at 120°C (248°F), and equipped with:

- 2.32.1.1 cast iron housing with flanged inlet and outlet with gauge taps, laser welded stainless steel impeller, bearing plate and shaft, stainless steel neck ring,

- dynamically balanced rotor with stainless steel cladding, and tungsten carbide sleeve type motor bearings;
- 2.32.1.2 squirrel cage, self-venting motor suitable for a VFD, cooled by pumped fluid and complete with stator housing drain holes to permit condensed water to drain;
- 2.32.1.3 bolt-on, integrated, CSA or ETL certified variable frequency drive assembly with "AUTOADAPT" function which automatically adjusts proportional pressure and sets an efficient performance curve whenever possible, an operating panel with control modules and clear indications for pump flow rate and head, and a bus communication module for site connection into building automation system.
- 2.32.2 Manufacturers:
 - 2.32.2.1 Grundfos Canada Inc. "Magna" Series;
 - 2.32.2.2 Taco Canada Ltd. "Delta T".

3 EXECUTION

3.1 PIPING INSTALLATION REQUIREMENTS

- 3.1.1 Provide required hydronic piping. Pipe, unless otherwise specified, is to be:
 - 3.1.1.1 For pipe sizes up to and including 50 mm (2") diameter, Schedule 40 black steel, screwed, or type "L" hard copper with solder joints or pressure coupled joints;
 - 3.1.1.2 For pipe 65 mm (2-½") to 300 mm (12") dia. and larger, Standard weight grooved end black steel pipe, 10 mm (0.375") thickness, with grooved end fittings and couplings, or, Standard weight black steel pipe, 10 mm (0.375") thickness, with welding fittings and welded joints;
 - 3.1.1.3 For short branch connections, 25 mm (1") pipe diameter size and less, to heating equipment where structural obstructions occur and site bending of pipe is advantageous, a single length of type "L" soft copper.
 - 3.1.2 Slope horizontal piping mains to provide a minimum continuous up-grade of 25 mm (1") in 6 m (20') to high points. Slope branch supply and return piping connections to equipment a minimum of 25 mm (1") in 1.2 m (4'). Leave sufficient room at high points for installation and maintenance of air vents.
 - 3.1.3 Install automatic control valves, piping wells and similar piping and/or equipment mounted control components required for automatic temperature control systems supplied as part of the control work. Refer to drawing control diagrams and details.
 - 3.1.4 Connect equipment provided as part of the work of other sections with piping as indicated and/or required. Refer to pipe connection details on drawings.
 - 3.1.5 Provide screwed unions, removable mechanical joint couplings, or weld-on or solder-on flanges in piping at all connections to valves, strainers and similar piping system components which may need maintenance or repair, at equipment connections, in runs of piping exceeding 9 m (30') at 4.5 m (15') regular intervals to permit removal of sections of piping, and wherever else indicated on drawings.
 - 3.1.6 Provide shut-off valves in piping connections to equipment, to isolate piping risers, to isolate other sections of systems as shown, and wherever else indicated on drawings. Valves in piping to and including 50 mm (2") dia. are to be ball type. All other shut-off valves are to be ball or butterfly type unless otherwise specified. Locate valves so they are easily accessible. Wherever possible, install valves at uniform height. Provide chain operators for valves which are inaccessible for operation from floor level.
 - 3.1.7 Provide a check valve in discharge piping of every pump, and elsewhere in piping where shown on drawings. Where check valves are required in vertical piping, ensure they are suitable in all respects for the application. Check valves for vertical in-line and/or base mounted circulating pumps are integral with the discharge accessory.
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- 3.1.8 Provide a drain valve at base of each piping riser, in drain connections to equipment, in low points of horizontal piping, and wherever else shown and/or specified.
- 3.1.9 Provide circuit balancing valves in piping generally where shown on drawings but with exact locations in accordance with instructions of personnel doing system flow balancing work. Confirm locations prior to installation.
- 3.1.10 Grooved pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing. All couplings will meet Victaulic standards for visual inspection sizes 2" to 12". The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Install in accordance with manufacturer's latest recommendations. A Victaulic factory trained representative shall periodically visit the job site and review the installation for best practices. The installing Contractor shall correct any identified deficiencies. Victaulic product that has been examined and has not met the visual inspection criteria for proper installation must be corrected and re-examined by Victaulic prior to the completion of the project.

3.2 *INSTALLATION OF PRESSURE RELIEF VALVES*

- 3.2.1 Provide factory set pressure relief valves. Pipe discharge of each water piping relief valve to drain unless otherwise shown or specified.
- 3.2.2 Pipe discharge of each glycol solution piping relief valve back to system expansion tank or return piping.
- 3.2.3 Confirm relief valve settings.

3.3 *INSTALLATION OF AIR VENTS*

- 3.3.1 Provide an air vent in piping mains at all high points, at equipment connections, and wherever else shown and/or specified. Equip each air vent with a ball type shut-off valve. Install vents in 100 mm (4") dia. and larger piping and all vents in mechanical rooms in accordance with drawing detail.
- 3.3.2 Provide 9 mm (3/8") dia. copper drain piping from each automatic air vent to nearest suitable drain and terminate so discharge is visible. Identify drain piping.

3.4 *INSTALLATION OF STRAINERS*

- 3.4.1 Provide strainers in piping. Locate strainers so baskets are easily accessible and removable. Clean strainer baskets during and after piping system flushing and cleaning is complete, and before water quantity balancing commences.

3.5 *INSTALLATION OF EXPANSION COMPENSATORS*

- 3.5.1 Provide expansion compensation in piping.
 - 3.5.2 Generally, locate expansion compensation where shown, but with exact locations to suit piping as installed.
 - 3.5.3 Provide double pipe alignment guides in horizontal piping at each side of expansion compensation facilities to permit movement in axial direction only. Secure guides to building structure only.
 - 3.5.4 Provide a pipe guide at each side of expansion joints in vertical risers.
 - 3.5.5 When using grooved piping in a riser refer to a Victaulic riser design for anchor and guide locations.
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3.6 INSTALLATION OF PIPING ANCHORS

- 3.6.1 Provide anchors to secure piping to structure. Locate anchors generally where shown but with exact locations to suit piping as installed and requirements of reviewed anchor shop drawings.
- 3.6.2 When installation of anchors is complete, arrange, and pay for anchor design engineer to visit site to review anchor installation. Submit a signed letter with engineer's stamp from design engineer confirming each anchor is properly installed.

3.7 INSTALLATION OF AIR SEPARATOR

- 3.7.1 Provide an air separator in piping and connect with valved inlet and outlet piping.
- 3.7.2 Extend valved blowdown piping from bottom pipe connection tapping to nearest floor drain location.
- 3.7.3 Equip top pipe connection tapping with an automatic air vent, and piping as detailed.

3.8 INSTALLATION OF EXPANSION TANK

- 3.8.1 Provide an expansion tank.
- 3.8.2 Secure horizontal expansion tank in place from structure by means of properly sized galvanized steel hanger rods and support saddles supplied with tank.
- 3.8.3 Secure tank stand to a concrete housekeeping pad by means of machine bolts.
- 3.8.4 Brace and secure tank in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.8.5 Connect tank with system piping. Extend a drain line from tank piping and terminate drain line with a drain valve. Provide an air vent.
- 3.8.6 Provide a water make-up connection line complete with relief valve and pressure gauge and connect to system piping. Terminate make-up piping for connection to domestic cold water piping as part of the work of Section 22 11 00 – Facility Water Distribution. Check relief valve operation and adjust as required.
- 3.8.7 Check tank air charge and adjust to suit system.

3.9 INSTALLATION OF GLYCOL SOLUTION MIXING AND STORAGE TANK

- 3.9.1 Provide a mixing and storage tank and feed assembly for each glycol solution circulating system.
- 3.9.2 Secure tank stand to a concrete housekeeping pad. Connect with system piping. Refer to drawing detail.
- 3.9.3 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.9.4 Fill tank with, unless otherwise specified, a solution of 50% water, 50% propylene glycol, and test solution to confirm proper concentrations.
- 3.9.5 When installation is complete, test operation of assembly, including alarms, and adjust as required. Adjust pressure switch to suit glycol solution circulating system pressure.

3.10 INSTALLATION OF FLEXIBLE PIPING CONNECTIONS

- 3.10.1 Provide flexible connections in piping connections to equipment.
- 3.10.2 Install in accordance with manufacturer's instructions.

3.11 INSTALLATION OF CIRCULATING PUMPS

- 3.11.1 Provide centrifugal circulating pumps.
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- 3.11.2 Secure base mounted pumps in place on seismic rated structural steel bases with vibration isolators as specified in Section 20 05 48.13 – Vibration Controls for Mechanical Systems, and restrain as specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems. Provide flexible connectors in pump suction and discharge piping 450 mm (18") from suction and discharge connection accessories.
- 3.11.3 Secure base mounted pumps in place on a concrete housekeeping pad. Shim pump baseplate level using metal wedges prior to tightening bolts. When installation is complete and pump-motor alignment has been checked, fill void between pump base and housekeeping pad with KPM Industries Ltd. "In-Pakt" or equal non-shrink grout. Provide flexible connections in pump suction and discharge piping 450 mm (18") from suction and discharge connection accessories.
- 3.11.4 Floor mount vertical inline pumps with seismically rated neoprene vibration isolators as specified in Section 20 05 48.13 – Vibration Controls for Mechanical Systems, and seismically rated steel pump mounting brackets custom welded to suction and discharge connections of pump. For further mounting requirements, refer to Section 20 05 48.16 – Seismic Controls for Mechanical Systems. Provide flexible connectors in vertical suction and discharge piping 450 mm (18") above suction and discharge connection accessories.
- 3.11.5 Secure vertical inline pumps in place in accordance with requirements of drawing detail and provide flexible piping connections in vertical suction and discharge piping approximately 450 mm (18") above suction and discharge connection accessories.
- 3.11.6 Provide a shut-off valve and suction guide in pump suction piping, and a combination check-balance-shut-off valve assembly in pump discharge piping, installed in accordance with manufacturer's instructions. Remove suction guide start-up strainer screens after piping flushing and cleaning is complete. Combination check-balance-shut-off valve assemblies are to be 150 mm (6") away from pump discharge for discharge piping to 150 mm (6") dia., and 300 mm (12") away from pump discharge for discharge pipe larger than 150 mm (6") dia.
- 3.11.7 For pumps equipped with seal flush line filters, replace flush line filter cartridge when pipe flushing and cleaning is complete, and hand identified spare filter cartridges to Owner at site.
- 3.11.8 Supply variable frequency drives (VFD) for pumps as scheduled. Hand VFD's to electrical trade at site for installation as part of the electrical work.
- 3.11.9 Install horizontal inline pumps in place in vertical piping approximately 1.2 m (4') above floor in accordance with pump manufacturer's instructions.
- 3.11.10 If circulating pumps are used for piping flushing and cleaning, and pump seal flush line filters are not installed, replace pump mechanical seals when flushing and cleaning is complete.
- 3.11.11 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.11.12 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.11.13 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.12 FLUSHING AND CLEANING PIPING

- 3.12.1 Flush and clean new piping.

3.13 TESTING, ADJUSTING AND BALANCING

- 3.13.1 When work is complete and equipment is operating as intended, test, adjust and balance water flows in accordance with requirements specified in Section 20 05 93 – Testing,

Adjusting, and Balancing for Mechanical Systems, and Section 23 08 00 –
Commissioning of HVAC.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for all products specified in Part 2 of this section except for pipe and fittings.
- 1.1.2 Submit, in shop drawing form, a schematic piping diagram for each refrigerant piping system indicating pipe sizes, slopes, valves, traps, and piping specialties. Piping schematics must be reviewed, approved, and signed by refrigeration equipment manufacturers prior to being submitted to the Consultant for review.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit letters from equipment suppliers certifying proper installation and start-up of piping systems and equipment as specified in Part 3 of this section.

1.3 QUALITY ASSURANCE

- 1.3.1 Refrigerant piping systems are to be in accordance with CSA B52, Mechanical Refrigeration Code, and any applicable local Codes and Regulations.
- 1.3.2 Refrigerant piping installing contractor is to be certified by Technical Standards and Safety Authority (TSSA). Installing contractor is to install refrigerant piping in accordance with manufacturer's installation instructions and in accordance with local codes. Contractor is responsible for all regulatory approvals, if required. Upon completion of installation, documentation of refrigerant amount, test certificates and verification documentation, etc., is to be provided in a binder, in accordance with requirements of local authorities having jurisdiction.
- 1.3.3 Refrigerant piping and direct expansion refrigeration equipment must be installed by or under direct on site supervision of a licensed journeyman refrigeration mechanic.

2 PRODUCTS

2.1 PIPE, FITTINGS, AND JOINTS

- 2.1.1 Type ACR hard drawn seamless copper refrigerant tubing to ASTM B280, factory degreased, dehydrated and capped or nitrogen filled and capped, complete with factory washed and bagged wrought copper soldering fittings to ASME B16.22, and brazed joints made with high melting point silver brazing alloy conforming to AWS Classification BcuP-5.

2.2 PIPING LINE SETS

- 2.2.1 Equal to Great Lakes Copper Inc. "EZ-Roll" soft annealed copper to ASTM B280, suitable for use with refrigerant involved, factory cleaned and capped, and with sizes and lengths as required.

2.3 GENERAL RE: VALVES AND PIPING SPECIALTIES

- 2.3.1 Refrigerant valves and piping specialties specified below are to factory cleaned, degreased, and supplied to site with capped ends.

2.4 SHUT-OFF VALVES

- 2.4.1 Ball Valves
 - 2.4.1.1 ¼ turn, CSA certified forged brass ball valves, each suitable for a maximum working pressure of 3445 kPa (500 psi) and complete with carbon filled Teflon ball seals, 2 O-ring stem seals, a gasketed seal cap, a flow direction arrow cast

into body, a ball position indicator on stem, and extended copper tube connections to permit brazing the valve into line without disassembling valve.

- 2.4.1.2 Manufacturers:
(1) Mueller Industries Inc.;
(2) Sporlan Valve Co.;
(3) Superior Refrigeration Products/Sherwood.

2.4.2 Diaphragm Valves

- 2.4.2.1 Forged brass, frost-proof, Type 1 Series, CSA certified packless diaphragm valves, each suitable for a 3445 kPa (500 psi) working pressure and complete with an O-ring to prevent moisture from entering diaphragm chamber, one phosphor bronze and 2 stainless steel diaphragms, and extended copper tube brazing connections.
- 2.4.2.2 Manufacturers:
(1) Mueller Industries Inc.;
(2) Sporlan Valve Co.;
(3) Superior Refrigeration Products/Sherwood.

2.5 CHECK VALVES

- 2.5.1 Straight through type for valves 6.4 mm to 16 mm (¼" to 5/8") diameter, globe type for valves 22 mm (7/8") diameter and larger, each complete with extended tubing for brazing connections, and as follows:
- 2.5.1.1 straight through type check valves complete with a machined brass gasketed body, phosphor bronze spring, and neoprene seat;
- 2.5.1.2 globe type check valves complete with a cast bronze body, forged brass cap, phosphor bronze spring, Teflon seat disc, and neoprene O-ring seal.
- 2.5.2 Manufacturers:
- 2.5.2.1 Mueller Industries Inc.;
- 2.5.2.2 Sporlan Valve Co.;
- 2.5.2.3 Superior Refrigeration Products/Sherwood.

2.6 PIPING TRAPS

- 2.6.1 Mueller Industries Inc. Style No. WE-554P brazing end copper "P" traps.
- 2.6.2 Manufacturers:
- 2.6.2.1 Mueller Industries Inc.;
- 2.6.2.2 Sporlan Valve Co.;
- 2.6.2.3 Superior Refrigeration Products/Sherwood.

2.7 PRESSURE VESSEL RELIEF VALVES

- 2.7.1 Factory set pressure relief valves, straight through or angle type as required, each constructed in accordance with requirements of ANSI B9.1 and the ASME Code for Unfired Pressure Vessels, and each complete with a brass body, neoprene seat disc, and lead seal and locking wire.
- 2.7.2 Manufacturers:
- 2.7.2.1 Mueller Industries Inc.;
- 2.7.2.2 Sporlan Valve Co.;
- 2.7.2.3 Superior Refrigeration Products/Sherwood.

2.8 REFRIGERANT LIQUID MOISTURE INDICATORS

- 2.8.1 Forged brass, triple sealed, CSA certified liquid moisture indicators, each suitable for a maximum working pressure of 3445 kPa (500 psi) and complete with a liquid indicator
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which shows "FULL" when system is fully charged with refrigerant and remains blank when there is a restriction or shortage of refrigerant in liquid line, a moisture indicator which changes colour from blue to pink when moisture is present in system, a plastic dust cover, and extended copper tube brazing connections.

2.8.2 Manufacturers:

- 2.8.2.1 Mueller Industries Inc.;
- 2.8.2.2 Sporlan Valve Co.;
- 2.8.2.3 Superior Refrigeration Products/Sherwood.

2.9 **LIQUID LINE FILTER-DRIER**

2.9.1 Mueller Industries Inc. "Drymaster" CSA certified filter-driers, each suitable for a maximum 3445 kPa (500 psi) working pressure and complete with a combination of desiccants in a fluted briquette for drying, and a fluted briquette type filter.

2.9.2 Manufacturers:

- 2.9.2.1 Mueller Industries Inc.;
- 2.9.2.2 Sporlan Valve Co.;
- 2.9.2.3 Superior Refrigeration Products/Sherwood.

2.10 **FLEXIBLE PIPING CONNECTIONS**

2.10.1 Senior Flexonics Canada "VIBRA-SORBERS" phosphor bronze construction, factory cleaned, dried, and sealed flexible piping connections with copper tube brazing ends.

2.10.2 Manufacturers:

- 2.10.2.1 Senior Flexonics Canada;
- 2.10.2.2 The Metraflex Co.

2.11 **THERMOSTATIC EXPANSION VALVES**

2.11.1 Factory tested, balanced port design thermostatic expansion valves, with exact selection to suit the application and refrigerant used, each complete within a replaceable stainless steel diaphragm and welded element construction thermostatic element charged with hydraulic fluid, and removable inlet strainer.

2.11.2 Manufacturers:

- 2.11.2.1 Mueller Industries Inc.;
- 2.11.2.2 Sporlan Valve Co.;
- 2.11.2.3 Superior Refrigeration Products/Sherwood.

3 **EXECUTION**

3.1 **INSTALLATION OF REFRIGERANT PIPING, VALVES AND SPECIALTIES**

3.1.1 Provide required refrigerant piping. Piping is to be type ACR copper with wrought copper fittings. Install piping in accordance with requirements of reviewed refrigerant piping schematics referred to in Part 1 of this section.

3.1.2 Make refrigerant piping joints using a light coat of approved brazing flux applied to both pipe and fitting. Do not use acid flux. During brazing process, ensure pipe and fittings are kept full of nitrogen or carbon dioxide to prevent scale formation inside pipe and fitting.

3.1.3 Where shown or specified, use soft copper refrigerant piping line sets.

3.1.4 Provide shut-off valves to isolate each piece of equipment if shut-off valves are not supplied integral with equipment. Provide ball or diaphragm type shut-off valves inside building. Provide diaphragm shut-off valves outside building.

3.1.5 Provide a refrigerant charging valve for each system if such a valve is not supplied integral with equipment.

- 3.1.6 Provide refrigerant piping accessories shown and/or required and install in accordance with manufacturer's recommendations.
- 3.1.7 Provide required refrigerant.
- 3.1.8 Provide flexible connections at piping connections to roof mounted condensing units. Install in accordance with manufacturer's instructions.
- 3.1.9 Provide expansion valves where shown and/or required, each matched to coil and installed in accordance with manufacturer's instructions.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for all products specified in this section except shop fabricated ductwork and fittings.
- 1.1.2 Include capacity, throw and terminal velocity, noise criteria, and pressure drops with grille and diffuser shop drawing/product data sheet submission.
- 1.1.3 With shop drawing/product data sheet submission, supply evidence that fire rated duct manufacturer is ULC listed to size requirements shows on drawings.
- 1.1.4 Submit duct leakage test data prior to ductwork being covered from view.
- 1.1.5 Submit manufacturer's colour chart(s) for all items for which a finish colour is to be selected.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit proper installation certification from fire rated duct manufacturer as specified in Part 3 of this section.
- 1.2.2 Submit a site inspection and start-up report from fan filter diffuser manufacturer's representative as specified in Part 3 of this section.

1.3 MAINTENANCE MATERIAL SUBMITTALS

- 1.3.1 Supply and hand to Owner at Substantial Performance of the Work, a minimum of 10 identified (with tags) grille/diffuser volume control damper adjustment keys.

1.4 COORDINATION

- 1.4.1 Supply reviewed copies of ventilator/curb assembly shop drawings or product data sheets to trade who will cut roof openings for ventilators, and ensure openings are properly sized and located.

1.5 QUALITY ASSURANCE

- 1.5.1 Grilles and diffusers are to be tested and performance certified to ANSI/ASHRAE 70, Method of Testing the Performance of Air Outlets and Air Inlets.

2 PRODUCTS

2.1 GALVANIZED STEEL DUCTWORK

- 2.1.1 Galvanized steel sheet is to be hot dipped in accordance with requirements of ASTM A653. G60 galvanizing for bare uncovered duct to be finish painted. G90 for all other galvanizing.
- 2.1.2 Rectangular
 - 2.1.2.1 Lock forming grade hot dip galvanized steel, ASTM A653, shop fabricated, minimum 26 gauge.
- 2.1.3 Round
 - 2.1.3.1 Factory machine fabricated, spiral, mechanically locked flat seam, single wall duct, fittings and couplings.
- 2.1.4 Flat Oval
 - 2.1.4.1 Factory machine fabricated, single wall, 4-ply spiral lock seam duct, fittings and couplings.

2.2 GALVANIZED STEEL ROUND PVC COATED DUCTWORK

- 2.2.1 Factory made G90 galvanized steel, ASTM A653, spiral seam smooth wall round duct and fittings with metal gauges in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible for a 2.5 kPa (0.36 psi) pressure, with a 4 mm thick PVC coating permanently fused to both sides of the duct, fittings and sleeve joint pieces, and type 316 stainless steel sheet metal screws and support hardware.

2.3 FLEXIBLE METALLIC DUCTWORK

- 2.3.1 Bare
- 2.3.1.1 Spirally wound, semi-rigid, self-supporting corrugated aluminum duct with continuous triple lock seams, SMACNA Form "M-UN", CAN/ULC-S110 listed and labelled as a Class 1 Air Duct, constructed of dead soft aluminum strip, and supplied in 3 m (10') lengths.
- 2.3.2 Insulated
- 2.3.2.1 Spirally wound, semi-rigid, self-supporting corrugated aluminum duct with continuous triple lock seams, SMACNA Form "M-I", CAN/ULC-S110 listed and labelled as a Class 1 Air Duct, constructed of dead soft aluminum strip, supplied in 3 m (10') lengths and factory covered with 40 mm (1-½") thick, 12 kg/m³ (0.75 lb/ft³) density fibreglass insulation with a vinyl jacket meeting 25/50 flame spread and smoke developed requirements tested in accordance with CAN/ULC-S102.

2.4 FLEXIBLE CONNECTION MATERIAL

- 2.4.1 Waterproof, indoor-outdoor type flexible connection material meeting requirements of NFPA 90A, consisting of woven glass fibre fabric coated on both sides with synthetic rubber.
- 2.4.2 Manufacturers:
- 2.4.2.1 Duro Dyne Canada Inc. "DUROLON";
- 2.4.2.2 Dyn Air Inc. "HYPALON".
- 2.4.3 Waterproof, flameproof, high temperature flexible connection material meeting requirements of NFPA 90A, consisting of a woven glass fibre fabric coated on both sides with silicone rubber.
- 2.4.4 Manufacturers:
- 2.4.4.1 Duro-Dyne Canada Inc. "THERMAFAB";
- 2.4.4.2 Dyn Air Inc. "SILICON HI-T".

2.5 METAL DUCT SYSTEM JOINT SEALANT

- 2.5.1 ULC listed and labelled, premium grade, grey colour, water base, non-flammable duct sealer, brush, or gun applied, with a CAN/ULC S102 tested maximum flame spread rating of 5 and smoke developed rating of 0.
- 2.5.2 Manufacturers:
- 2.5.2.1 Johns Manville;
- 2.5.2.2 Manson Insulation;
- 2.5.2.3 Knauf Insulation.

2.6 ACOUSTIC LINING

- 2.6.1 Minimum 25 mm (1") thick acoustic lining material meeting 25/50 flame spread and smoke developed ratings tested in accordance with CAN/ULC S102, meeting NFPA 90A, ASTM C1071, and ASTM G21 requirements, not supporting microbial growth, flexible for
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round ducts, board type for rectangular ducts, consisting of a bonded fiberglass mat coated on inside (airside) face with a black fire-resistant coating.

- 2.6.2 Manufacturers:
- 2.6.2.1 Johns Manville;
 - 2.6.2.2 Manson Insulation;
 - 2.6.2.3 Knauf Insulation.

2.7 KITCHEN EXHAUST DUCT EXPANSION JOINT

- 2.7.1 Hyspan Precision Products Inc. Series 2500 flanged, carbon steel, rectangular expansion joints sized to suit ductwork.

2.8 FACTORY INSULATED FIRE RATED DUCTWORK

- 2.8.1 Equal to DuraSystems Barriers Inc. "DuraDuct HP" or "DuraDuct GNX" duct, 2 hour fire rated, constructed, ULC listed and labelled for fire rated ventilation applications. Duct is constructed of a galvanized steel inner liner, a galvanized steel outer jacket, and all required fittings and accessories, including support hardware.

2.9 CASING AND PLENUM MATERIAL AND ACCESSORIES

- 2.9.1 Unless otherwise specified, casing and plenum material is to be same as connecting duct material.
- 2.9.2 Accessories such as access doors and drain pans are to be constructed of same material as casing and plenum and are to be in accordance with Chapter 6 of SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.10 ACOUSTIC PLENUM PANELS

- 2.10.1 Vibro-Acoustics Ltd. type "AP", 100 mm (4") thick panels with acoustic media meeting NFPA 90A requirements sandwiched between minimum #24 gauge galvanized sheet steel, with airside face perforated, access doors where shown, and with acoustic performance as follows:

Octave Bands, (Hz)	125	250	500	1000	2000	4000
Transmission Loss	21	28	39	50	53	56
Absorption Coefficient	0.7	0.9	0.99	0.99	0.9	0.9

- 2.10.2 Acoustic plenum media factory encapsulated in sealed DuPont "Tedlar" polyvinyl fluoride film to ensure no media enters the airstream.

- 2.10.3 Manufacturers:
- 2.10.3.1 Vibro-Acoustics Ltd.;
 - 2.10.3.2 Kinetics Noise Control Inc.;
 - 2.10.3.3 Carrier Corp. – Racan;
 - 2.10.3.4 Haakon Industries;
 - 2.10.3.5 Price Industries Inc;
 - 2.10.3.6 Alumavent.

2.11 PLENUM ACCESS DOORS

- 2.11.1 Factory fabricated, double wall insulated access doors, sized as indicated on drawings, and constructed of same material as connecting ductwork in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit operating pressure of the system.

2.12 ROUND TO RECTANGULAR DUCT CONNECTIONS

- 2.12.1 Equal to Flexmaster Canada Ltd. galvanized steel, flared, flanged or notched "Spin-On" round duct take-off collars with locking dampers in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.13 SPLITTER DAMPERS

- 2.13.1 Minimum 20 gauge damper blade constructed of same material as duct, reinforced as required to suit blade size, system velocity, and to prevent "chatter", and complete with operating hardware equal to DynAir Inc. #Q-50 "DYN-A-QUAD S-S" quadrant regulator with RW-50 backup washers to prevent leakage, long square bearing pin, and slide pin.

2.14 AIR TURNING VANES

- 2.14.1 For square elbows, multiple-radius turning vanes interconnected with bars, adequately reinforced to suit pressure and velocity of system, constructed of same material as duct they are associated with, and in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- 2.14.2 For short branch ducts at grille and diffuser connections, air extractor type each equipped with a matching bottom operated 90° opposed blade volume control damper, constructed of same material as duct it is associated with and in accordance with requirements and details in ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.

2.15 MANUAL BALANCING (VOLUME) DAMPERS

- 2.15.1 Flanged and drilled, single or parallel blade (depending on damper size) manual balancing dampers, each constructed of same material as connecting ductwork unless otherwise specified, each designed to maintain internal free area of connecting duct, and each complete with:
- 2.15.1.1 hexagonal or square shaft extension through frame;
 - 2.15.1.2 non-stick, non-corrosive synthetic bearings for rectangular dampers, flange stainless steel bearings for round dampers;
 - 2.15.1.3 blade stops for single blade dampers, designed to prevent blade from moving more than 90°;
 - 2.15.1.4 linkage for multiple blade dampers;
 - 2.15.1.5 locking hand quadrant damper operator with, for insulated ducts 50 mm (2") standoff mounting.
- 2.15.2 Rectangular Dampers: Nailor Industries Inc. 1800 Series, maximum size 1.2 m x 1.2 m (4' x 4') for a single damper.
- 2.15.3 Round Dampers: Nailor Industries Inc. model 1890, maximum 600 mm (24") diameter, equipped with a minimum 200 mm (8") deep frame, and blade stiffeners where required.
- 2.15.4 Multiple Rectangular Damper Section Assembly: Rectangular assembly supplied with the dampers or site constructed, of same material as damper and designed for tight and secure mounting of individual dampers.
- 2.15.5 Manufacturers:
- 2.15.5.1 Nailor Industries Inc.;
 - 2.15.5.2 T.A. Morrison & Co. Inc. "TAMCO";
 - 2.15.5.3 Greenheck Fan Corp.;
 - 2.15.5.4 Ruskin Co.

2.16 BACKDRAFT DAMPERS

- 2.16.1 Nailor Industries Model 1370CB counterbalanced backdraft dampers, vertical or horizontal mounting, 50 mm (2") wide, sized as shown and complete with:
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- 2.16.1.1 extruded 6063-T5 aluminum frame, 2.3 mm (0.090") nominal wall thickness, with mitred corners;
- 2.16.1.2 extruded 6063-T5 aluminum blades, 1.3 mm (0.050") nominal wall thickness on 92 mm (3-5/8") centres, and with extruded PVC blade seals;
- 2.16.1.3 corrosion-resistant synthetic bearings;
- 2.16.1.4 adjustable plated steel counterweights mounted internally in the airstream;
- 2.16.1.5 concealed blade linkage located out of the airstream.
- 2.16.2 Manufacturers:
 - 2.16.2.1 Nailor Industries Inc.;
 - 2.16.2.2 T.A. Morrison & Co. Inc. "TAMCO";
 - 2.16.2.3 Greenheck Fan Corp.;
 - 2.16.2.4 Ruskin Co.

2.17 FUSIBLE LINK DAMPERS

- 2.17.1 Curtain blade type, dynamic, galvanized steel (unless otherwise specified) fusible link dampers, ULC classified to CAN/ULC S112 and in accordance with NFPA 90A requirements, factory tested for closure under airflow, 1-1/2 hour or 3 hour rated as required, and complete with a constant force type 301 stainless steel closure spring, a blade lock assembly, a steel sleeve, retaining angles, and, unless otherwise specified, a 74°C (165°F) rated standard fusible link.
- 2.17.2 Fusible link dampers are to be Type "B" or Type "C" (as required) with folded curtain blade out of air stream except where damper size or location requires use of type "A" dampers with curtain blade in air stream.
- 2.17.3 Dampers in ductwork other than galvanized steel are to be as specified above but constructed of type 316 stainless steel.
- 2.17.4 Manufacturers:
 - 2.17.4.1 Nailor Industries Inc.;
 - 2.17.4.2 Greenheck Fan Corp.;
 - 2.17.4.3 Ruskin Co.;
 - 2.17.4.4 Price Industries (E.H. Price).

2.18 COMBINATION FIRE/SMOKE DAMPERS

- 2.18.1 Nailor Industries Series 1221, ULC listed to CAN/ULC S112 and CAN/ULC S112.1, meeting requirements of NFPA 80, 90A, 92, 101 and 105, consisting of type A, B, or C fusible link fire dampers as required and a fail-safe, opposed blade, normally closed, motor operated smoke damper complete with factory installed and tested 120 V electric actuator.
- 2.18.2 ULC 1-1/2 hour fire rated and ULC Class I leakage rated for smoke, and equipped with a 74°C (165°F) ULC classified fusible link that will cause damper to close and lock independent of actuator when duct temperature reaches maximum temperature of damper assembly.
- 2.18.3 Supply damper with factory installed sleeves of minimum 400 mm (16") length, field verified by contractor dependent on wall thickness. Caulk sleeves to ULC requirements and constructed of 20 gauge for sizes up to 2.1 m (84") wide and 18 gauge for sizes greater than 2.1 m (84") wide.
- 2.18.4 Dampers in ductwork other than galvanized steel are to be as specified above but constructed of type 316 stainless steel.
- 2.18.5 Manufacturers:
 - 2.18.5.1 Nailor Industries Inc.;
 - 2.18.5.2 Greenheck Fan Corp.;
 - 2.18.5.3 Ruskin Co.;
 - 2.18.5.4 Price Industries (E.H. Price).

2.19 SMOKE DAMPERS

- 2.19.1 Multi-blade type, fail-safe, dynamic, galvanized steel (unless otherwise specified) smoke dampers, ULC classified to CAN/ULC-S112.1, ULC Class I leakage rated for smoke, meeting requirements of NFPA 90A, NFPA 92, NFPA 101, and NFPA 105, normally closed, low pressure drop design, dynamically tested, each complete with jamb and blade seals, linkage concealed in the frame, a steel sleeve to suit the opening, and an electric actuator to automatically close damper upon receiving an external signal, and to automatically open damper when system is reset.
- 2.19.2 Dampers in ductwork other than galvanized steel are to be as specified above but constructed of type 316 stainless steel.
- 2.19.3 Manufacturers:
 - 2.19.3.1 Nailor Industries Inc.;
 - 2.19.3.2 Greenheck Fan Corp.;
 - 2.19.3.3 Ruskin Co.;
 - 2.19.3.4 Price Industries (E.H Price).

2.20 ROOF DUCT SUPPORTS

- 2.20.1 Equal to PHP Systems Design Model PHP-D adjustable duct support assemblies sized to suit duct size, each assembly complete with injection moulded recycled plastic and carbon black bases and tubular hot dip galvanized steel framing.

2.21 PRESSURE RELIEF DOORS

- 2.21.1 Greenheck model PRAD (positive) or VRAD (negative) pressure relief doors constructed of same material as duct or plenum they are associated with, each complete with a sealing gasket, special latches, cable assembly with spring to limit door opening to maximum 80° and factory set, field adjustable pressure relief magnet assembly.
- 2.21.2 Size access doors to match requirements of system so pressure drop through open blow-out door at required flow rate will not exceed rated pressure of duct system.
- 2.21.3 Manufacturers:
 - 2.21.3.1 Greenheck Fan Corp.;
 - 2.21.3.2 United Enertech.

2.22 DUCT ACCESS DOORS

- 2.22.1 In accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, with sizes suitable in all respects for purpose for which they are provided, and, unless otherwise specified, constructed of same material as duct they are associated with.

2.23 DUCTWORK DRAIN POINTS

- 2.23.1 Equal to Ductmate Canada Ltd. "Moisture Drain", 20 mm (¾") diameter moisture drains with galvanized sheet metal funnel, and chrome plated brass threaded drain, nut, and cap.

2.24 INSTRUMENT TEST PORTS

- 2.24.1 Equal to Duro-Dyne of Canada Ltd. #IP1 or #IP2 (to suit insulation thickness where applicable) gasketed, leakproof instrument test ports for round or rectangular ducts as required, each complete with a neoprene expansion plug and a plug securing chain.
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2.25 WIRE MESH (BIRDSCREEN)

- 2.25.1 Heavy-gauge galvanized steel or aluminum mesh, 12 mm x 12 mm (½" x ½") secured in a rigid galvanized steel or aluminum framework, sized as indicated on drawings, and constructed so as to be removable.

2.26 LOUVRES

- 2.26.1 Price Industries Inc. DE439 or DE635, 100 mm (4") or 150 mm (6") deep (to suit wall thickness) factory assembled stationary, drainable, louvres sized as indicated on drawings, each AMCA water penetration and air performance certified, constructed of welded, extruded, alloy 6063-T5 aluminum with drainable blades, mounting and securing hardware to suit the application, and 12 mm (½") mesh aluminum birdscreen in an aluminum frame.
- 2.26.2 Acoustical Louvres: Price Industries Inc. Model QA1245 300 mm (12") deep, welded, extruded alloy 3003-H14 aluminum, storm-proof, stationary, drainable acoustical louvers, AMCA water penetration and air performance certified, with high density mineral wool acoustic media secured to blades and protected by perforated aluminum, sound ratings in accordance with ASTM E90 and ASTM E413, and mounting and securing facilities as required.
- 2.26.3 Louvres are to be factory finished with a finish equal to PPG Industries "Duramar" fluoropolymer powder coating over primer with colour as selected from manufacturer's standard colour range.
- 2.26.4 Manufacturers:
- 2.26.4.1 Price Industries Inc.;
 - 2.26.4.2 The Airolite Co. LLC;
 - 2.26.4.3 Construction Specialties;
 - 2.26.4.4 Nailor Industries Inc.;
 - 2.26.4.5 Kinetics Noise Control Inc.
 - 2.26.4.6 Greenheck Fan Corp.
 - 2.26.4.7 Ventex.

2.27 LOUVRE BLANK-OFF PANELS

- 2.27.1 Insulated, framed, sandwich construction panels consisting of 40 mm (1-½") thick rigid insulation (meeting NFPA 90A requirements) between minimum 20 gauge galvanized sheet steel with exterior face of panels finished to match finish of exterior wall louvres.

2.28 BRICK AND BLOCK VENTS

- 2.28.1 Equal to Price Industries Inc. vents constructed of 6063-T5 alloy extruded aluminum, sized as shown, complete with stainless steel fasteners, aluminum rod vertical supports on minimum 300 mm (12") centres, #2 mesh fixed aluminum screen, and all required accessories to suit the application.
- 2.28.2 Vent(s) to be factory finished with a finish equal to a baked "Kynar 500-XL" colour coat and a clear coat over cleaned and primed metal with colour as selected from manufacturer's standard colour range.

2.29 FIRE STOP FLAPS AND THERMAL BLANKET MATERIAL

- 2.29.1 Rectangular or round, ULC listed and labelled, blade type galvanized steel fire stop flaps in accordance with CAN/ULC-S112, Standard Methods of Fire Test of Fire-Damper Assemblies and CAN/ULC-S112.2, Standard Method of Fire Test of Ceiling Firestop Flap Assemblies, each complete with 22 gauge G60 galvanized steel blade(s) and frame, a 74°C (165°F) fusible link, and, for dampers 300 mm (12") and larger, ceramic fibre insulation on both sides of the blades.

- 2.29.2 Ceramic fibre material in accordance with 25/50 flame spread/smoke developed ratings when tested to CAN/ULC-S102 and of a thickness to suit required fire rating.

2.30 GRILLES AND DIFFUSERS

- 2.30.1 Grilles and diffusers of type, size, capacity, finish, and arrangement as shown on drawings and in accordance with drawing schedule, each equipped with all required mounting and connection accessories to suit mounting location and application.
- 2.30.2 Manufacturers:
- 2.30.2.1 Price Industries Inc.;
 - 2.30.2.2 Anemostat;
 - 2.30.2.3 Krueger Division of Air System Components Inc.;
 - 2.30.2.4 Titus;
 - 2.30.2.5 Nailor Industries Inc.;
 - 2.30.2.6 Tuttle & Bailey.

2.31 FAN FILTER DIFFUSERS

- 2.31.1 Factory assembled and leakage tested, suspended ceiling mount, modular assemblies, each ULC and CSA or ETL certified and labelled, consisting of a fan-motor and HEPA filter enclosed in a metal plenum, designed for unidirectional vertical flow of filtered air over a cleanroom space. Sound performance of each is not to exceed 50 dBA measured 765 mm (30") from filter face at 0.5 m/s (90 FPM). Units are to be in accordance with the Institute of Environmental Services and Technology Recommended Practices IEST RP CCOO1, HEPA and ULPA Filters, and IEST RP CCOO2, Unidirectional-Flow, Clean-Air Devices. Each unit is to be equipped with:
- 2.31.1.1 plenum and face frame: airtight low profile design, constructed of type 304 stainless steel with aluminum interior parts including an extruded aluminum filter frame with air by-pass seal, an inlet duct connection collar, sound insulation meeting 25/50 flame spread/smoke developed ratings when tested to CAN/ULC S102, a static pressure port, eyebolts at each corner;
 - 2.31.1.2 fan and motor: removable, consisting of a blower wheel encased in a strategically shaped enclosure a direct connected to a vibration isolated 1/3 HP ECM brushless DC motor with permanent built-in inverter programmed for constant volume airflow and equipped with a 2.4 m (8') length of power cord with plug;
 - 2.31.1.3 filter: HEPA ultra low penetration air (ULPA) filters, 99.9995% efficient on 0.12 µm micron particles, latched into fan plenum and protected by a perforated screen attached with quarter-turn thumb-wheel fasteners, and room side replaceable;
 - 2.31.1.4 diffuser face: perforated, laminar flow face constructed of aluminum with quarter-turn fasteners for removal and access to fan-motor and filter;
 - 2.31.1.5 mounting gasket: roll type gasket material supplied with units for site installation on T-bar ceiling members;
 - 2.31.1.6 factory secured seismic restraint connection hardware.

2.32 INTAKE AND EXHAUST WALL BOX

- 2.32.1 Equal to Reversomatic SWBLM wall boxes leakproof seamless construction, extruded aluminum grille, sized as shown, complete with stainless steel fasteners, neoprene backdraft damper, and all required accessories to suit the application.
- 2.32.2 Vent(s) to be factory finished with a finish equal to a baked "Kynar 500-XL" colour coat and a clear coat over cleaned and primed metal with colour as selected from manufacturer's standard colour range.
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3 EXECUTION

3.1 CLEANLINESS REQUIREMENTS FOR HANDLING AND INSTALLATION OF DUCTWORK

- 3.1.1 Handle and install ductwork in accordance with CSA Z317.2, Special Requirements for Heating, Ventilation, and Air-Conditioning (HVAC) Systems in Healthcare Facilities and SMACNA's Duct Cleanliness for New Construction Guidelines at the Advanced Level.
- 3.1.2 Handle and install ductwork in accordance with SMACNA's Duct Cleanliness for New Construction Guidelines at the Advanced Level.

3.2 FABRICATION AND INSTALLATION OF GALVANIZED STEEL DUCTWORK

- 3.2.1 Provide required ductwork, rectangular, round and/or flat oval. Where rectangular ductwork is shown, round or flat oval ductwork of equivalent cross-sectional area is acceptable.
- 3.2.2 It is to be understood that all duct dimensions shown on drawings are clear internal dimensions.
- 3.2.3 Unless otherwise specified, construct and install ductwork in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit duct pressure class designation of minimum 500 Pa (2" w.c.) positive or negative as applicable, a minimum velocity of 10 m/s (2000 fpm), and so ductwork does not "drum". Flat surfaces of rectangular ductwork are to be cross-broken or beaded per SMACNA standards. Duct system sealing is to meet ANSI/SMACNA Seal Class A requirements.
- 3.2.4 Variable air volume ductwork from supply fans to boxes is as above but rectangular duct take-offs are double side straight taper type with a take-off length equal to 0.5 times the branch duct width but minimum 150 mm (6") length, and double taper side is to have an included angle of minimum 60°.
- 3.2.5 Confirm routing of all ductwork at site and site measure ductwork prior to fabrication. Duct dimensions may be revised to suit site routing and building element requirements, if dimension revisions are reviewed with and approved by the Consultant. Duct routing and/or dimension revisions to suit conditions at site are not grounds for a claim for an extra cost.
- 3.2.6 Refer to structural drawings. Where ductwork is to be run within or through open web steel joists, ductwork shown on mechanical drawings is schematic only and is to be altered as required to suit steel joist configuration, spacing, panel points, and cross-bridging at no additional cost.
- 3.2.7 Wherever ductwork is required at locations where sprayed fireproofing is applied to building construction, install ductwork only after fireproofing work is complete and do not compromise fire rating of sprayed fireproofing.
- 3.2.8 Install (but do not connect) duct system mounted automatic control components supplied as part of the automatic control work.
- 3.2.9 Where indicated, provide duct connections to fan powered heat transfer equipment with integral coils.
- 3.2.10 Flange connect ductwork to hot water reheat coils in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Coils will be suspended independent of connecting ductwork as part of the heat transfer work.
- 3.2.11 Support horizontal rectangular ducts inside building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but use trapeze hangers with, unless otherwise specified, galvanized steel channels, and galvanized steel hanger rods for exposed ducts and concealed ducts wider than 500 mm (20"). Support hardware constructed of same material as duct for metal duct, and, unless otherwise specified, type 316 stainless steel for non-metal duct. Supports for "heavy" duct such as cementitious

- core duct is to be suitable in all respects for the application and approved by the Consultant.
- 3.2.12 Support round and flat oval ducts inside building in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, but, unless otherwise specified, for both uninsulated and insulated ducts exposed in finished areas, use bands and secure at top of duct to a hanger rod, all similar to Ductmate Canada Ltd. type "BA". If duct is insulated, size strap to suit diameter of insulated duct. Unless otherwise specified, duct support hardware for metal duct is constructed of same material as duct, and for non-metal duct, type 316 stainless steel.
- 3.2.13 Where flanged duct joints are used, do not locate joints in wall or slab openings, or immediately at wall or slab openings. Do not use flanged joints for exposed uninsulated ducts in finished areas.
- 3.2.14 Where watertight horizontal ductwork is required, construct ducts without bottom longitudinal seams. Solder or weld joints of bottom and side sheets. Seal all other joints with duct sealer. Slope horizontal duct to hoods, risers, or drain points. Provide drain points. Provide watertight ductwork for:
- 3.2.14.1 ductwork outside building or otherwise exposed to the elements;
 - 3.2.14.2 dishwasher exhaust;
 - 3.2.14.3 shower exhaust ducts from grilles to duct main or riser;
 - 3.2.14.4 minimum of 3 m (10') upstream and downstream of duct mounted humidifiers or humidifier manifolds;
 - 3.2.14.5 fresh air intakes;
 - 3.2.14.6 wherever else shown.
- 3.2.15 Leakage Testing:
- 3.2.15.1 Ductwork leakage is not to exceed following:
 - (1) ductwork to 2" W.C. Class, 1% of total air quantity handled by respective fans;
 - (2) ductwork exceeding 2" W.C. Class, 2% of total air quantity handled by respective fans.
 - 3.2.15.2 Leakage testing is to be performed by the Testing, Adjusting and Balancing (TAB) agency in accordance with SMACNA HVAC Air Duct Leakage Test Manual and is to be witnessed by the Consultant.
 - 3.2.15.3 Leakage test all ductwork.
 - 3.2.15.4 Be responsible for following:
 - (1) preparing duct systems for leakage testing prior to installation of external insulation including capping duct runouts and provision of final tap-in for test equipment;
 - (2) schedule testing with TAB agency in advance, be present for all testing and ensure notice is given to the Consultant so they may witness testing;
 - (3) resealing and/or replacement of defective ductwork;
 - (4) bearing all costs associated with retesting ductwork which has failed to pass leakage testing.
- 3.2.16 Seal all ductwork in accordance with SMACNA Seal Class "A", except for round duct with self-sealing gasketed fittings and couplings which does not require site applied sealant. Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant applications will be rejected and must be repaired or replaced with a neat application of sealant.
- 3.2.17 Apply sealants by brush or gun to cleaned metal surfaces. Where bare ductwork is exposed apply neat uniform lines of sealant. Randomly brushed, sloppy looking sealant
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applications will be rejected and must be repaired or replaced with a neat application of sealant.

- 3.2.18 Clean exterior exposed (uninsulated) ducts and coat with a heavy full coverage of Bakor #410-02 black metal paint.
- 3.2.19 Where dissimilar metal ducts are to be connected, isolate ducts by means of flexible duct connection material.
- 3.2.20 Round exposed ductwork in Gymnasium is to be 2 metal gauges heavier than standard metal gauge for same size duct, and duct hangers are to be pairs of 9.5 mm ($\frac{3}{8}$ ") diameter hanger rods secured to 40 mm ($1\frac{1}{2}$ ") wide 12 gauge galvanized steel split clamps around full circumference of duct at maximum 1.8 m (72") centres. Provide double nuts and lock washers on each hanger rod above and below each clamp.
- 3.2.21 Equip ducts with a dimension of 600 mm (24") and larger and located in mechanical equipment rooms of any kind with hanger rods equipped with double deflection neoprene rod isolation hangers properly sized for associated load. Also refer to Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.2.22 In addition to SMACNA duct construction standards specified above, ductwork is to be constructed and installed to meet seismic requirements of British Columbia Building Code and ANSI/SMACNA The Seismic Restraint Manual: Guidelines for Mechanical Systems.

3.3 INSTALLATION OF FLEXIBLE DUCTWORK

- 3.3.1 Provide maximum 1.8 m (6') fully stretched, long lengths of flexible ductwork for connections between galvanized steel duct mains and branches, and necks of ceiling grilles and diffusers. Do not install flexible ductwork through walls, even if shown on drawings.
- 3.3.2 At rectangular galvanized steel duct, accurately cut holes and provide flanged or "Spin-in" round flexible duct connection collars. Seal joints with duct sealer.
- 3.3.3 Install flexible ducts as straight as possible and support in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, and secure at each end with nylon or stainless steel gear type clamps, and seal joints. Provide long radius duct bends where they are required.
- 3.3.4 Do not penetrate fire barriers with flexible duct.

3.4 INSTALLATION OF ACOUSTIC LINING

- 3.4.1 Provide acoustic lining in ductwork in locations as follows:
 - 3.4.1.1 wherever shown and/or specified on drawings;
 - 3.4.1.2 supply ductwork downstream of air terminal boxes for a distance of 2.4 m (8') measured along duct and outward from box in all directions;
 - 3.4.1.3 all transfer air ducts.
- 3.4.2 Install lining in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible, however, for all installations regardless of velocity, at leading and trailing edges of duct liner sections, provide galvanized steel nosing channel in accordance with detail entitled Flexible Duct Liner Installation found in the ANSI/SMACNA manual referred to above.

3.5 INSTALLATION OF FIRE RATED DUCTWORK

- 3.5.1 Provide 2 hour fire rated ductwork.
 - 3.5.2 Install ductwork in strict accordance with duct manufacturer's instructions using support hardware supplied with duct.
 - 3.5.3 When installation is complete, arrange, and pay for duct manufacturer to visit site and examine duct installation. Make any revisions requested by manufacturer, and when
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manufacturer is satisfied with installation, obtain and submit a letter certifying proper installation in accordance with ULC requirements.

3.6 *INSTALLATION OF SHEET STEEL KITCHEN GREASE EXHAUST DUCTWORK*

- 3.6.1 Provide welded sheet steel kitchen grease exhaust ductwork from exhaust hood(s) to roof mounted exhaust fans, all in accordance with requirements of NFPA 96. Construct ductwork watertight with continuous externally welded seams and joints, cleanouts, duct expansion provisions, riser residue traps, etc.
- 3.6.2 Clean and prime coat ground welds in black steel ducts.
- 3.6.3 Support ductwork at not greater than 1.5 m (5') intervals and ensure fasteners at hangers do not penetrate duct. Install without forming dips, sags, or traps where grease residue might collect, and locate access door/cleanouts for ease of maintenance.
- 3.6.4 Slope horizontal ductwork 25 mm per 300 mm (1" per foot) back to exhaust hood.

3.7 *INSTALLATION OF IN-SLAB DUCTWORK*

- 3.7.1 Provide in-slab concrete encased ductwork, complete with required fittings and accessories.
- 3.7.2 Install duct with support brackets supplied with duct and coordinated with location of reinforcing steel, post tensioning cables, and any other structural slab component. Install duct in strict accordance with manufacturer's installation instructions and requirements of the Consultant. Ensure all joints are water-tight.
- 3.7.3 Confirm finish of exterior discharge fittings with the Consultant prior to ordering.

3.8 *INSTALLATION OF CASINGS AND PLENUMS*

- 3.8.1 Provide required shop or site fabricated casings and plenums. Unless otherwise specified or shown, construct casings and plenums of same material as connecting duct system.
- 3.8.2 Construct and install casings and plenums in accordance with Chapter 6 of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible to suit systems' pressure classification. Ensure plenums and casings secured to building structure are gasketed air-tight and equipped with angle reinforcing.
- 3.8.3 Provide drain pans with accessible trapped drains for fresh air intake plenums, and wherever else shown.
- 3.8.4 In addition to SMACNA duct construction standards specified above, casings and plenums are to be constructed and installed to meet seismic requirements of British Columbia Building Code and ANSI/SMACNA - The Seismic Restraint Manual: Guidelines for Mechanical Systems.

3.9 *INSTALLATION OF ACOUSTIC PANELS*

- 3.9.1 Provide acoustic panels for plenums. Integrate acoustic plenums with standard casings and plenums. Install acoustic panels in strict accordance with manufacturer's instructions. Seal panels with acoustic caulking where pipes, ducts or conduit penetrate and make air and watertight.
 - 3.9.2 Provide floor to ceiling high acoustic plenums where shown, each complete with required framing, including framing for access doors and other openings, each structurally designed to resist excessive deflection or bowing, constructed to be air-tight when subjected to a pressure differential of 2.48 kPa (0.36 psi), and designed so any one panel can be removed without dismantling entire plenum.
 - 3.9.3 Provide acoustic type access doors where shown, and provide acoustic caulking at all locations where acoustic plenums abut building walls or slabs, and at all points where pipe, ducts or conduit penetrate acoustic panels.
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3.10 INSTALLATION OF CASING AND PLENUM ACCESS DOORS

- 3.10.1 Provide access doors into all site or shop fabricated casings and plenums requiring access, and wherever shown.
- 3.10.2 Construct access doors to open in or out to suit positive and negative pressures of system.
- 3.10.3 Provide pitot tube openings in access doors where required for system air quantity balancing purposes.
- 3.10.4 Provide suitably sized, engraved, red-white laminated Lamacoid warning nameplates on access doors into casings and plenums where equipment is located, i.e. fans.

3.11 INSTALLATION OF ROUND TO RECTANGULAR DUCT CONNECTIONS

- 3.11.1 Cut round holes in rectangular ducts and provide round to rectangular lock-in fittings with dampers for connection of flexible round ductwork.

3.12 INSTALLATION OF SPLITTER DAMPERS

- 3.12.1 Provide splitter dampers in supply ductwork at branch duct connections off supply air mains, and wherever else shown and/or specified on drawings. Install splitter dampers so they cannot vibrate and rattle and so damper operation mechanisms are in an easily accessible and operable location. Ensure operators for dampers in insulated ducts are equipped with stand-off mounting brackets.

3.13 INSTALLATION OF TURNING VANES

- 3.13.1 Provide turning vanes in ductwork elbows where shown on drawings and wherever else required where, due to site installation routing and duct elbow radius, turning vanes are recommended in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- 3.13.2 Provide volume extractor type turning vanes in short branch supply duct connections off mains to grilles and diffusers where shown and/or specified.

3.14 INSTALLATION OF MANUAL BALANCING (VOLUME) DAMPERS

- 3.14.1 Provide manual balancing dampers as required to provide a fully balanced system, including but not limited to in all open end ductwork, in all duct mains, and wherever else shown and/or specified.
- 3.14.2 Install dampers so operating mechanism is accessible and positioned for easy operation, and so dampers cannot move or rattle. Ensure operating mechanisms for dampers in insulated ducts are complete with stand-off mounting brackets.
- 3.14.3 Where a duct for which a balancing damper is required has dimensions larger than dimensions of maximum size volume damper available, provide multiple dampers bolted together in a properly sized assembly, or bolted to a heavy-gauge black structural steel angle or channel framework which is properly sized. Seal to prevent air by-pass, and provide connecting linkage.
- 3.14.4 Confirm exact damper locations with personnel doing air quantity balancing testing work and install dampers to suit. Include for providing 5 additional dampers at no additional cost.

3.15 INSTALLATION OF BACKDRAFT DAMPERS

- 3.15.1 Provide backdraft dampers.
 - 3.15.2 Install and secure dampers so they cannot move or rattle.
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3.16 INSTALLATION OF FUSIBLE LINK DAMPERS

- 3.16.1 Provide fusible link dampers. Ensure damper rating (1-½ or 3 hr) is suitable for fire barrier it is associated with.
- 3.16.2 Install dampers with retaining angles on all 4 sides of sleeve on both sides of damper and connect with ductwork in accordance with damper manufacturer's instructions and details, and Code requirements.
- 3.16.3 Provide expansion clearance between damper or damper sleeve and opening in which damper is required. Ensure openings are properly sized and located, and all voids between damper sleeve and opening are properly sealed to maintain rating of fire barrier.
- 3.16.4 Where size of fire barrier opening requires use of a sectionalized fire damper assembly, provide multiple fusible link dampers (sized to CAN/ULC S112) bolted together in a properly sized assembly or bolted to a heavy-gauge black structural steel angle or channel framework.

3.17 INSTALLATION OF COMBINATION FIRE/SMOKE DAMPERS

- 3.17.1 Provide combination fire/smoke dampers. Install dampers with retaining angles on all 4 sides of each side of damper, and, where required, connect with ductwork, all in accordance with damper manufacturer's instructions and details, and Code requirements.
- 3.17.2 Coordinate damper installation with electrical work where electrical connections to damper actuators are specified.

3.18 INSTALLATION OF SMOKE DAMPERS

- 3.18.1 Provide smoke dampers. Install dampers with retaining angles on all 4 sides of sleeve on both sides of damper and connect with ductwork in accordance with damper manufacturer's instructions and details, and Code requirements.
- 3.18.2 Coordinate damper installation with electrical work where electrical connections to damper actuators are specified.
- 3.18.3 Where size of fire barrier opening requires use of a sectionalized fire damper assembly, provide multiple smoke dampers (sized to CAN/ULC-S112) bolted together in a properly sized assembly or bolted to a heavy-gauge black structural steel angle or channel framework.

3.19 INSTALLATION OF FLEXIBLE CONNECTION MATERIAL

- 3.19.1 Provide a minimum of 100 mm (4") of flexible connection material where ducts, plenums, and/or easings connect to fans, and wherever else shown or specified.
- 3.19.2 Rigidly secure a minimum of 75 mm (3") of duct material (minimum #24 gauge) to each edge of flexible fabric and to fan, duct, plenum, etc., in accordance with ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible. Ensure connections to flexible fabric material are arranged and supported so as to not impose any external forces on the fabric.

3.20 INSTALLATION OF ROOF MOUNTED DUCT SUPPORTS

- 3.20.1 Supply supports for roof mounted ductwork.
 - 3.20.2 Hand adjustable structural supports to roofing trade on roof for installation and flashing into roof construction as part of roofing work. Accurately mark exact locations and spacing of structural supports and supervise installation. Provide properly sized hot dip galvanized structural steel angles between structural supports and secure in place on support studs. Support ductwork on the angles and provide galvanized steel banding to secure ducts to the angles.
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- 3.20.3 Accurately mark location and spacing of roof support assemblies. At each plastic base location, carefully scrape away loose roof ballast (gravel) and all other debris and dirt. Prime existing membrane with a primer which is compatible with existing roofing components. Set bases in adhesive in accordance with manufacturer's installation instructions. Scrape loose ballast back around and on bases. Install framing, and install ductwork on the cross-members. Secure ductwork to cross-members with galvanized steel banding.

3.21 INSTALLATION OF PRESSURE RELIEF DOORS

- 3.21.1 Provide pressure release access doors to prevent duct system explosion or implosion as a result of a duct obstruction, i.e. closed fire damper, which prevents normal air flow through the system. Size access doors in accordance with requirements of Part 2 of this section.
- 3.21.2 Where pressure release doors are shown in suction ducts or plenums, mount access door assembly so door swings in and latch mechanism is on the inside of duct or plenum. If latch mechanism is not accessible, provide a standard access door at latch side of the pressure release access door for maintenance purposes.
- 3.21.3 Adjust each latch mechanism by means of the adjusting pin to suit static pressure of the particular system in accordance with latch mechanism manufacturer's instructions.

3.22 INSTALLATION OF DUCT ACCESS DOORS

- 3.22.1 Provide access doors in ductwork for access to all components which will or may need maintenance and/or repair, including reheat coils. Install in accordance with requirements of ANSI/SMACNA HVAC Duct Construction Standards Metal and Flexible.
- 3.22.2 Identify access doors provided for fusible link damper maintenance with "FLD" stencil painted or marker type red lettering and ensure doors are properly located for damper maintenance.
- 3.22.3 When requested, submit a sample of proposed duct access doors for review.
- 3.22.4 Where sectionalized fusible link dampers and/or balancing dampers are provided in large ducts, provide a plenum type access door to suit, and adequately reinforce ductwork to suit access door installed.

3.23 INSTALLATION OF INSTRUMENTS TEST PORTS

- 3.23.1 Provide instrument test ports in all main ducts at connections to fans, plenums, or casings, in all larger branch duct connections to mains, and wherever else required for proper air quantity balancing and testing.
- 3.23.2 Locate test ports where recommended by personnel performing air quantity testing and balancing work.

3.24 INSTALLATION OF WIRE MESH (BIRDSCREEN)

- 3.24.1 Provide framed, removable wire mesh panels over openings in ducts and/or walls where shown and/or specified on drawings. Rigidly secure in place but ensure panels are removable.
- 3.24.2 Provide wire mesh panels for open-end return air ducts in ceiling spaces whether shown on drawings or not.

3.25 INSTALLATION OF LOUVRES

- 3.25.1 Provide louvres for wall openings.
 - 3.25.2 Install louver assemblies and secure in place in accordance with manufacturer's instructions and details.
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- 3.25.3 Confirm exact louvre sizes and finish prior to ordering.

3.26 INSTALLATION OF LOUVRE BLANK-OFF PANELS

- 3.26.1 Provide blank-off panels for inactive portions of exterior wall louvres.
- 3.26.2 Secure panels in place with non-ferrous hardware so they cannot move or rattle, yet are easily removable.
- 3.26.3 Confirm exact finish of panels prior to fabrication.

3.27 INSTALLATION OF BRICK AND BLOCK VENTS

- 3.27.1 Supply brick or block vents for installation in exterior walls.
- 3.27.2 Hand assemblies to masonry trade for installation.
- 3.27.3 Accurately mark exact locations and coordinate installation.

3.28 INSTALLATION OF FIRE STOP FLAPS AND THERMAL BLANKETS

- 3.28.1 Provide fire stop flaps in duct connection necks of grilles and diffusers installed in ULC fire rated suspended ceiling systems where shown on drawings.
- 3.28.2 Provide thermal blanket material to completely cover grille and/or diffuser pans above suspended ULC fire rated ceilings. Cut, install, and secure in place in accordance with manufacturer's instructions and ULC requirements.

3.29 INSTALLATION OF GRILLES AND DIFFUSERS

- 3.29.1 Provide grilles and diffusers. Wherever possible, grilles and diffusers are to be product of same manufacturer.
- 3.29.2 Unless otherwise specified connect grilles and diffusers in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible.
- 3.29.3 Exactly locate grilles and diffusers to conform to final architectural reflected ceiling plans and detailed wall elevations, and to conform to final lighting arrangement, ceiling layout, ornamental and other wall treatment.
- 3.29.4 Equip supply diffusers having a basic 4-way or all round air pattern for operation in 1-, 2-, or 3-way pattern where indicated on drawings.
- 3.29.5 Attach troffer type diffusers associated with typical ceiling mounted fluorescent lighting fixtures to the fixtures on floor prior to fixture installation in ceiling. When fixtures are installed, connect diffuser boots with flexible ductwork.
- 3.29.6 Provide sheet metal plenums, constructed of same material as connecting duct, for linear grilles and/or diffusers where shown. Construct and install plenums in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible. Where individual sections of linear grilles or diffusers are not equipped with a volume control device, equip duct connection collar(s) with volume control device(s).
- 3.29.7 Where linear type diffusers/grilles are installed in suspended T-bar ceilings, clip diffusers/grilles in place using clip supplied by diffuser/grille manufacturer.
- 3.29.8 Confirm grille and diffuser finishes prior to ordering.

3.30 INSTALLATION OF FAN FILTER DIFFUSERS

- 3.30.1 Provide fan filter diffusers.
 - 3.30.2 Exactly locate fan filter diffusers to conform to final architectural reflected ceiling plans, and to conform to final lighting arrangement and locations of ceiling equipment.
 - 3.30.3 Install in strict accordance with manufacturer's instructions, including gasket tape on T-bar ceiling members at unit locations. Plug each unit into an adjacent ceiling receptacle.
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- 3.30.4 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.30.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.30.6 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.30.7 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including, but not limited to, a full operation and maintenance demonstration.

3.31 SUPPLY OF DOOR GRILLES

- 3.31.1 Supply door grilles as shown and scheduled.
- 3.31.2 Hand grilles to appropriate trade at site for installation.

3.32 INSTALLATION OF ROOF MOUNTED GRAVITY VENTILATORS

- 3.32.1 Provide roof mounted gravity ventilators.
- 3.32.2 Supply a roof mounting curb with each ventilator and hand curbs to roofing trade on roof for mounting and flashing into roof construction as part of the roofing work. Site assemble gravity ventilators as required, and secure in place on curbs.
- 3.32.3 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.32.4 Install dampers in curb damper tray and secure in place.

3.33 INSTALLATION OF INTAKE AND EXHAUST WALL BOXES

- 3.33.1 Supply brick or block vents for installation in exterior walls.
- 3.33.2 Hand assemblies to masonry trade for installation.
- 3.33.3 Accurately mark exact locations and coordinate installation.

3.34 DUCT SYSTEM PROTECTION, CLEANING AND START-UP

- 3.34.1 Temporarily cover all open ends of ducts during construction.
- 3.34.2 Remove all dirt and foreign matter from entire duct systems and clean duct system terminals and interior of air handling units prior to operating fans.
- 3.34.3 Prior to starting any supply air handling system provide 50 mm (2") thick glass fibre construction filters at fan equipment in place of permanent filters.
- 3.34.4 Provide cheesecloth over duct system inlets and outlets and run system for 24 hours, after which remove cheesecloth and construction filters, and install new permanent filters.
- 3.34.5 Include all labour for a complete site walk-through with testing and balancing personnel following route of all duct systems to be tested, adjusted, and balanced for the purpose of confirming proper position and attitude of dampers, location of pitot tube openings, and any other work affecting testing and balancing procedures. Perform corrective work required as a result of this walk-through.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop product data sheets for silencers. Include all construction, acoustic and aerodynamic performance data, and details with submission. Acoustical data is to demonstrate that duct systems with silencers will reduce mechanical fan system noise to required levels in occupied spaces.
- 1.1.2 Submit manufacturer's test data to indicate results of factory tests on the silencers prior to shipment.
- 1.1.3 Submit a copy of the silencer manufacturer's National Voluntary Laboratory Accreditation Program (NVLAP) accreditation certificate for ASTM E477 test standards.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit an installation certification letter from silencer manufacturer as specified in Part 3 of this section.

1.3 QUALITY ASSURANCE

- 1.3.1 Silencer performance must be substantiated by laboratory testing in a duct-to-reverberant room test facility according to ASTM E477, Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers.
- 1.3.2 Silencer acoustic media and any lining/wrapping material must have a maximum flame spread rating of 25 and a smoke developed rating of 50 when tested in accordance with CAN/ULC S102, Surface Burning Characteristics of Building Materials, and Accessories.
- 1.3.3 All silencer surfaces in contact with airstream are to be in accordance with ANSI/ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Vibro-Acoustics Ltd.;
- 2.1.2 Kinetics Noise Control Vibron Products Group;
- 2.1.3 Price Industries Inc.

2.2 GENERAL RE: SILENCERS

- 2.2.1 Silencers are to be factory fabricated by same manufacturer and are to be in accordance with drawing schedule, and tested in accordance with ASTM E477 through National Voluntary Laboratory Accreditation Program (NVLAP) with valid accreditation certificate.
 - 2.2.2 Silencer inlet and outlet dimensions are to be equal to duct sizes shown on drawings. Unless otherwise shown or specified, transitions will not be permitted.
 - 2.2.3 Silencers are to be constructed in accordance with SMACNA HVAC Duct Construction Standards Metal and Flexible, to suit duct system pressure and velocity classification. Unless otherwise specified, casing seams and joints are to be lock-formed and sealed or stitch welded and sealed, and silencers are to be constructed so as not to fail when subjected to an internal static pressure of 3.9 kPa (8" wg).
 - 2.2.4 Perforated steel is to be adequately stiffened to ensure flatness and form, and welds are to be shop painted with zinc rich paint.
 - 2.2.5 Silencers are to be shipped with factory installed end caps.
 - 2.2.6 Galvanized steel is to be in accordance with ASTM A653.
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2.3 OUTER CASING MATERIALS

- 2.3.1 Rectangular Straight and Transitional Straight Silencers: minimum #22 gauge lock forming quality galvanized steel.
- 2.3.2 Elbow and Transitional Elbow Silencers: minimum #18 gauge for elbow lock forming quality galvanized steel.
- 2.3.3 High Transmission Loss (HTL) Rectangular and Elbow Silencers: #16 or #10 gauge stitch-welded and caulked galvanized steel in accordance with drawing schedule.
- 2.3.4 Circular Silencers: Lock forming quality galvanized steel with minimum gauges as follows:
 - 2.3.4.1 300 mm to 660 mm (12" to 26") dia. - #22 gauge;
 - 2.3.4.2 675 mm to 1.52 m (27" to 60") dia. - #18 gauge;
 - 2.3.4.3 1.55 m to 2.13 m (61" to 84") dia. - #16 gauge.

2.4 INTERIOR BAFFLE-LINER-BULLET MATERIAL

- 2.4.1 Minimum #22 gauge lock forming quality galvanized steel.

2.5 INTERIOR BAFFLE TRANSITION

- 2.5.1 Transitioning for interior transition silencers is to occur internal to silencer such that height of air passage is uniformly changing with the length of the air passage.

2.6 ACOUSTIC MEDIA MATERIAL

- 2.6.1 Except for no media silencers, and unless otherwise specified, inert, inorganic glass fibre of a density to obtain specified acoustic performance, packed under not less than 5% compression to eliminate voids due to vibration and settling.
- 2.6.2 For silencers as specified and/or scheduled, acoustic quality insulation which does not contain any formaldehydes, phenolic resins, or volatile organic compounds that can off-gas, but containing cotton fibres treated with an EPA registered non-toxic borate solution, "flash dried" to actively inhibit the growth of mould, mildew, bacteria, and fungi.
- 2.6.3 No media silencers are not to contain absorptive media of any kind, achieve attenuation with controlled impedance membranes and broadly tuned resonators.

2.7 ACOUSTIC MEDIA PROTECTION MATERIAL

- 2.7.1 Material for lining/wrapping acoustic media to help prevent shedding and erosion, in accordance with drawing schedule, is to be:
 - 2.7.1.1 Tedlar film material separated from perforated metal liner with a 12 mm (½") thick acoustically transparent spacer;
 - 2.7.1.2 glass fibre cloth.

2.8 ALTERNATIVE SILENCER MATERIALS

- 2.8.1 Where indicated on drawing silencer schedule, types 304 or 316 stainless steel or aluminum silencer material is to be used.

3 EXECUTION

3.1 INSTALLATION OF SILENCERS

- 3.1.1 Provide silencers. Ensure silencers are installed with airflow arrows in the direction of airflow.
 - 3.1.2 Support each silencer independent of connecting ductwork.
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- 3.1.3 Properly layout ductwork for silencer locations to provide a minimum of 5 diameters of straight duct upstream of silencer and 10 diameters of straight duct downstream of silencer.
- 3.1.4 Unless otherwise specified, do not install silencers in walls or slabs.
- 3.1.5 Where cross-talk silencers penetrate partition walls, seal joint between perimeter of silencer and the wall, on both sides of the wall, with proper acoustic caulking.
- 3.1.6 Seal all silencer connections to ducts with proper fire/smoke rated duct sealer.
- 3.1.7 When silencer installations are complete, arrange, and pay for silencer manufacturer to examine silencer installations. Perform any corrective work required by manufacturer, then obtain from manufacturer and submit a signed letter certifying proper installation and operation of all silencers.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Centrifugal fans.
- 1.1.2 Utility fans.
- 1.1.3 Inline fans.
- 1.1.4 Ceiling fans.
- 1.1.5 Destratification fans.
- 1.1.6 Residential range hoods.

1.2 SUBMITTALS

- 1.2.1 Submit shop drawings/product data sheets for fans and accessories. Include following:
 - 1.2.1.1 certified fan performance curves at specified operating point with flow, static pressure and HP clearly plotted;
 - 1.2.1.2 certified sound power data that conforms to specified levels;
 - 1.2.1.3 product data sheets for all accessories;
 - 1.2.1.4 product data sheets for fan motors.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Submit with delivery of each unit a copy of the factory inspection report, and include a copy of each report with O&M Manual project closeout data.
- 1.3.2 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this section.
- 1.3.3 Supply reviewed copies of fan/curb assembly shop drawings or product data to trade who will cut roof openings for fans, and ensure openings are properly located.
- 1.3.4 Supply reviewed copies of fan assembly shop drawings or product data to trade who will form/prepare wall openings for fans, and ensure openings are properly located.
- 1.3.5 Submit a signed copy of destratification fan manufacturer's 5 year extended parts and labour warranty.
- 1.3.6 Submit a signed copy of ceiling mounted fan manufacturer's extended 3 year warranty.
- 1.3.7 Training attendance records.

1.4 QUALITY ASSURANCE

- 1.4.1 Fan manufacturers, as applicable, are to be current members of the Air Movement and Control Association International Inc. (AMCA), and fans are to be rated (capacity and sound performance) and certified in accordance with requirements of following standards:
 - 1.4.1.1 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - 1.4.1.2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
 - 1.4.1.3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;
 - 1.4.1.4 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;
 - 1.4.1.5 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans.

2 PRODUCTS

2.1 CENTRIFUGAL FANS

- 2.1.1 Centrifugal fans in accordance with drawing schedule, each capable of operating over the complete pressure class limits as specified in AMCA Standard 99-16.
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- 2.1.2 Continuously welded heavy-gauge steel housing, braced and reinforced as required to prevent vibration or pulsation, equipped with a discharge flange, spun, aerodynamically designed inlet cones or venturies with wire grid guards, drain plug, and epoxy enamel coated both inside and outside to a 3 mm dry film thickness.
- 2.1.3 Continuously welded, stable, non-overloading wheel with die-formed steel blades and, unless otherwise required, a cast iron hub, statically and dynamically balanced prior to assembly, then balanced as an assembly and braced and secured to base prior to shipment.
- 2.1.4 AISI C1040 or C1050 hot rolled steel fan shaft, accurately turned, ground, polished, and ring gauged for accuracy, and sized for a first critical speed of at least 1.25 times the maximum rated speed for fan, and heavy-duty, grease lubricated, ball or roller, self-aligning pillow block type bearings selected for an AFBMA L-10 minimum average bearing life in excess of 200,000 hours, and equipped with extended copper lubrication lines terminated in lubrication fittings immediately inside fan section access door.
- 2.1.5 NEMA Premium TEFC motor, adjustable V-belt drive selected for 40% service factor based on motor nameplate data, and OSHA guard, all in accordance with requirements of Section 20 05 00 – Common Work Results for Mechanical.
- 2.1.6 Fan and motor support base is to be rigid, welded structural steel, vibration isolated base with steel cross members, factory cleaned, deburred, and finished with epoxy enamel, and complete with a slide type motor base and stable, colour coded spring mounts with sound pads selected to suit static deflection and maximum equipment load and to operate at not greater than 2/3 solid load, and shipping restraints.
- 2.1.7 Unless otherwise specified, finish is to consist of rust inhibiting primer applied to cleaned and deburred metal surfaces prior to assembly, then a second coat of primer after assembly and an air dried epoxy enamel finished coat both inside and outside to a 3 mm dry film thickness.
- 2.1.8 Factory secured seismic restraint connection hardware.
- 2.1.9 Manufacturers:
 - 2.1.9.1 Twin City Fan and Blower;
 - 2.1.9.2 Loren Cook Co.;
 - 2.1.9.3 Greenheck Fan Corp.;
 - 2.1.9.4 CML Northern Blower;
 - 2.1.9.5 PennBarry.

2.2 EXPLOSION-PROOF CENTRIFUGAL FANS

- 2.2.1 Explosion-proof centrifugal fans in accordance with drawing schedule, each capable of operating over complete pressure class limits as specified in AMCA Standard 99-2408 and rated Spark A in accordance with AMCA Standard 99-0401, Classification for Spark Resistant Construction.
 - 2.2.2 Housing constructed as per ASTM Standard 99-0401 to suit "Spark" classification, with a wheel direct connected to an explosion-proof TEFC motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, statically and dynamically balanced prior to assembly, then balanced as an assembly and secured to base prior to shipment.
 - 2.2.3 Rigid, welded structural steel, vibration isolated fan support base with steel cross members, factory cleaned, deburred, and finished with epoxy enamel, and complete with stable, colour coded spring mounts with sound pads selected to suit static deflection and maximum equipment load and to operate at not greater than 2/3 solid load, and shipping restraints.
 - 2.2.4 Factory secured seismic restraint connection hardware.
 - 2.2.5 Manufacturers:
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- 2.2.5.1 Twin City Fan and Blower;
- 2.2.5.2 Loren Cook Co.;
- 2.2.5.3 Greenheck Fan Corp.;
- 2.2.5.4 CML Northern Blower;
- 2.2.5.5 PennBarry.

2.3 UTILITY FANS

- 2.3.1 Centrifugal, single width and inlet, factory run tested utility fans in accordance with drawing schedule, and capable of operating over complete pressure class limits as specified in AMCA Standard 2408.
- 2.3.2 Rotatable, continuously welded heavy-gauge steel housing, braced and reinforced as required to prevent vibration or pulsation, equipped with a spun, aerodynamically designed inlet cone, and an attached welded steel bearing and motor support platform.
- 2.3.3 Riveted aluminum or welded steel wheel, statically and dynamically balanced.
- 2.3.4 For belt driven fans only, AISI C1040 or C1045 hot rolled steel shaft, accurately turned, ground, polished, and ring gauged for accuracy, and sized for a first critical speed of at least 1.43 times maximum rated speed for fan, equipped with heavy-duty, grease lubricated, ball, pillow block type bearings, selected for a minimum average AFBMA L-50 bearing life of 200,00 hours at the maximum fan RPM, and secured to bearing support platform, and an adjustable V-belt drive with OHSA guard (weather cover) in accordance with requirements of Section 20 05 00 – Common Work Results for Mechanical.
- 2.3.5 NEMA Premium TEFC motor conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical.
- 2.3.6 Unless otherwise specified, the finish is to consist of rust inhibiting primer applied to cleaned and deburred metal surfaces prior to assembly, then a second coat of primer after assembly and an air dried epoxy enamel finished coat both inside and outside to a 3 mm dry film thickness.
- 2.3.7 Factory secured seismic restraint connection hardware.
- 2.3.8 Manufacturers:
 - 2.3.8.1 Twin City Fan and Blower;
 - 2.3.8.2 Loren Cook Co.;
 - 2.3.8.3 Greenheck Fan Corp.;
 - 2.3.8.4 CML Northern Blower;
 - 2.3.8.5 PennBarry.

2.4 CENTRIFUGAL INLINE FANS

- 2.4.1 Centrifugal, ULC listed, factory run tested rectangular inline fans in accordance with drawing schedule.
 - 2.4.2 Heavy-gauge galvanized steel housing with removable side panels to permit removal of power assembly without disturbing duct connections, universal mounting brackets and hardware including spring vibration isolators to accommodate horizontal or vertical mounting as required, a flanged inlet panel with inlet venturi, a flanged outlet panel, both with duct connection collars, and galvanized steel wire grid fan inlet/outlet guard(s).
 - 2.4.3 Non-overloading aluminium wheel with backward inclined blades with matching inlet venturi, statically and dynamically balanced as an assembly.
 - 2.4.4 For belt-drive fans only, hot rolled steel shaft, accurately turned, ground, and polished, and sized for a first critical speed of at least 1.25 times maximum rated speed for fan, and heavy-duty, self-aligning pillow block type bearings selected for an AFBMA L-50 minimum average life in excess of 500,000 hours and equipped with lubrication line and fitting, and an adjustable V-belt drive with guard conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical.
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- 2.4.5 TEFC motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, mounted out of the airstream, complete with a cover, and factory pre-wired to a NEMA 4 disconnect switch.
- 2.4.6 For fans as scheduled, factory supplied accessories as follows:
 - 2.4.6.1 for fans as scheduled, housing insulation (lining), consisting of neoprene spray coated glass fibre semi-rigid insulation meeting NFPA 90A requirements and 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, permanently secured in place with no exposed edges;
 - 2.4.6.2 for fans as scheduled, a galvanized steel filter box with frame suitable for 25 mm (2") thick disposable panel type filters;
 - 2.4.6.3 factory secured seismic restraint connection hardware.
- 2.4.7 Manufacturers:
 - 2.4.7.1 Twin City Fan and Blower;
 - 2.4.7.2 Loren Cook Co.;
 - 2.4.7.3 Greenheck Fan Corp.;
 - 2.4.7.4 JencoFan;
 - 2.4.7.5 Carnes Company Inc.

2.5 PLENUM FANS

- 2.5.1 Centrifugal airfoil design plenum fans in accordance with drawing schedule, designed without a scroll type housing, and capable of operating over complete pressure class limits as specified in AMCA Standard 99-2408.
 - 2.5.2 Heavy-gauge reinforced steel inlet plate with perimeter square formed lip, spun steel inlet cone bolted to inlet plate for smooth airflow into venturi shaped inlet cone of the fan wheel, and a welded structural steel framework forming a mounting base and bearing support platform welded to the inlet plate.
 - 2.5.3 Non-overloading wheel with 9 backward inclined, die-formed, airfoil design steel blades continuously welded to a spun inlet cone, back plate, and cast iron hub, statically and dynamically balanced as an assembly, and designed for critical speeds of at least 1.25 times maximum class speed.
 - 2.5.4 For belt driven fans, AISI C1040 or C1050 hot rolled steel shaft, accurately turned, ground, polished and ring gauged for accuracy, and sized for a first critical speed of at least 1.25 times maximum rated speed for fan, and heavy-duty, grease lubricated, ball or roller self-aligning pillow block type bearings selected for an AFBMA L-10 minimum average life in excess of 200,000 hours and equipped with extended copper tube lubrication lines terminated in accessible lubrication fittings, and an adjustable V-belt drive selected for 40% service factor based on motor nameplate data and conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
 - 2.5.5 NEMA Premium TEFC motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
 - 2.5.6 Rigid, welded structural steel, vibration isolated fan and motor support base with steel cross members, factory cleaned, deburred, and finished with epoxy enamel, and complete with slide type motor base, and stable, colour coded spring mounts with neoprene sound pads selected to suit static deflection and to operate at not greater than 2/3 solid load, and equipped with shipping restraints.
 - 2.5.7 Rigid, open mesh galvanized steel screen enclosure with fan wheel access facilities, and a removable galvanized steel mesh inlet screen.
 - 2.5.8 Unless otherwise specified, factory finish is to consist of rust inhibiting primer applied to cleaned and deburred surfaces prior to assembly, then a second coat of primer after assembly and an air dried epoxy enamel finish applied to all inside and outside surfaces to a 3 mm dry film thickness.
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2.5.9 Factory secured seismic restraint connection hardware.

2.5.10 Manufacturers:

2.5.10.1 Twin City Fan and Blower;

2.5.10.2 Loren Cook Co.;

2.5.10.3 Greenheck Fan Corp.;

2.5.10.4 CML Northern Blower;

2.5.10.5 PennBarry.

2.6 ROOF MOUNTED EXHAUST FANS

2.6.1 Centrifugal, ULC listed, factory run tested roof mounted exhaust fans in accordance with drawing schedule.

2.6.2 Spun aluminium housing with deep venturi inlet, aluminium curb cap with continuously welded corners, pre-punched mounting holes, galvanized steel or aluminium bird screen, and EMT conduit chase to the motor compartment.

2.6.3 Centrifugal, non-overloading aluminum wheel with backward inclined blades matched to inlet venturi, statically and dynamically balanced as an assembly.

2.6.4 For belt-drive fans only, hot rolled steel shaft, accurately turned, ground, and polished, and sized for a first critical speed of at least 1.25 times maximum rated speed for fan, and one-piece grease lubricated pillow block type bearings selected for an AFBMA L-50 minimum average life in excess of 500,000 hours at maximum catalogue operating speed and equipped with a lubrication fitting, and a heavy-gauge galvanized steel adjustable V-belt drive with guard conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical.

2.6.5 Motors are to conform to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, mounted on vibration isolation in a compartment outside of the airstream, and factory pre-wired to a NEMA 4 disconnect switch.

2.6.6 Prefabricated, minimum 300 mm (12") high heavy-duty aluminum roof mounting curb with factory installed wood nailer, 40 mm (1-½") thick insulation, continuously welded seams, and damper tray.

2.6.7 For fans as scheduled, factory supplied accessories as follows:

2.6.7.1 gravity backdraft damper with #20 gauge galvanized steel frame and #26 gauge aluminum blades with felt edge blade seals;

2.6.7.2 non-corrosive motorized damper with linkage, end switch, and motor with voltage to match fan motor;

2.6.7.3 continuous non-corrosive piano type curb hinge to permit access to fan, damper and connecting duct, complete with retaining chain and a security hasp to prevent removal of unit from curb cap and prevent building entry through connecting ductwork;

2.6.7.4 2-speed switch and 2-speed double winding 1-phase motor in accordance with Section 20 05 00 – Common Work Results for Mechanical;

2.6.7.5 factory secured seismic restraint connection hardware.

2.6.8 Manufacturers:

2.6.8.1 Twin City Fan and Blower;

2.6.8.2 Loren Cook Co.;

2.6.8.3 Greenheck Fan Corp.;

2.6.8.4 JencoFan;

2.6.8.5 Carnes Company Inc.

2.7 SIDEWALL PROPELLER FANS

2.7.1 Axial flow type, ULC listed, factory run tested propeller fans in accordance with drawing schedule.

- 2.7.2 Heavy-gauge galvanized steel drive component frame bolted or welded to formed galvanized steel fan panel equipped with formed flanged edges, pre-punched mounting holes, and a deep formed inlet venturi.
- 2.7.3 Fabricated steel blades unless otherwise specified, welded to a heavy-gauge steel hub, and dynamically balanced.
- 2.7.4 For belt-drive fans only, AISI 1045 cold rolled steel shaft, accurately turned, ground, and polished, and sized for a first critical speed of at least 1.25 times maximum rated speed for fan, and grease lubricated or permanently lubricated, sealed, ball type pillow block bearings selected for an AFBMA L-50 minimum average life in excess of 200,000 hours at maximum fan RPM, with a variable pitch adjustable V-belt drive with guard conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical.
- 2.7.5 Motor in accordance with requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
- 2.7.6 Unless otherwise specified, all bare steel surfaces are to be cleaned, primed, and factory finished with epoxy equipment enamel.
- 2.7.7 Factory supplied accessories as follows:
 - 2.7.7.1 #16 gauge G90 galvanized steel wall box with removable screen guard, equipped with mounting flanges with pre-punched holes;
 - 2.7.7.2 back draft damper with galvanized steel frame, aluminum blades with felt edge seals, stainless steel shaft, and OHSA damper guard;
 - 2.7.7.3 galvanized steel weather hood with removable galvanized steel wire mesh bird screen, with mounting flanges equipped with pre-punched mounting holes;
 - 2.7.7.4 OHSA motor side guard with galvanized steel side panels and removable galvanized steel wire mesh screen;
 - 2.7.7.5 factory secured seismic restraint connection hardware.
- 2.7.8 Manufacturers:
 - 2.7.8.1 Twin City Fan and Blower;
 - 2.7.8.2 Loren Cook Co.;
 - 2.7.8.3 Greenheck Fan Corp.;
 - 2.7.8.4 JencoFan;
 - 2.7.8.5 Carnes Company Inc.;
 - 2.7.8.6 PennBarry.

2.8 CORROSION RESISTANT CENTRIFUGAL FANS

- 2.8.1 Centrifugal FRP fans in accordance with drawing schedule, with drive arrangement and configuration as indicated on drawings, and capable of operating over complete pressure class limits as specified in AMCA Standard 99-2408.
- 2.8.2 Aerodynamically designed housing with high efficiency inlet, manufactured from resins, UV inhibited, reinforced with fibreglass, and with bolts holding housing to support plate encapsulated in FRP, and no uncoated metal in contact with corrosive air stream. Each assembly is to be complete with graphite impregnated interior casing, lifting lugs, type 304 stainless steel fasteners, a FRP ridge inside casing to divert condensation from dripping over hub and shaft, a flanged inlet and outlet, and an impeller inspection and service access door.
- 2.8.3 Backward curved FRP wheel electronically statically and dynamically balanced after assembly, with an integral metal back plate encapsulated in resin and with hub extended to outside housing, a removable FRP cap to cover impeller end of shaft, and a vacuum hub seal to prevent contaminated air from escaping from fan housing.
- 2.8.4 For belt driven fans, type 316 stainless steel shaft, accurately turned, ground, polished, and ring gauged for accuracy, and sized for a first critical speed of at least 1.25 times maximum rated speed for fan, and complete with guard, and heavy-duty, sealed, grease lubricated, ball or roller, self-aligning pillow block type bearings selected for an AFBMA L-

10 minimum average bearing life in excess of 200,000 hours, and equipped with extended copper lubrication lines terminated in lubrication fittings at exterior of fan assembly, and an adjustable V-belt drive selected for 50% service factor based on motor nameplate data, with FRP OHSA guard in accordance with requirements of Section 20 05 00 – Common Work Results for Mechanical.

- 2.8.5 NEMA Premium TEFC motor conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical.
- 2.8.6 Rigid, welded structural steel unitary fan and motor support base, factory cleaned and finished with 4 to 6 mm thick baked powder epoxy enamel.
- 2.8.7 Factory secured seismic restraint connection hardware.
- 2.8.8 Manufacturers:
 - 2.8.8.1 M. K. Plastics Corp.;
 - 2.8.8.2 New York Blower Co.;
 - 2.8.8.3 Pasticair Inc.

2.9 VANEAXIAL FANS

- 2.9.1 Vaneaxial, ULC listed, factory run tested fans in accordance with drawing schedule.
 - 2.9.2 Heavy-gauge welded ASTM A-569 hot rolled steel housing with inlet and outlet flanges, and, on the discharge side of fan wheel, aerodynamically designed stationary straightening guide vanes welded to both inner cylinder and fan housing interior.
 - 2.9.3 Propeller type wheel, solid, one-piece casting of A356-T6 aluminium with 7 airfoil shape blades and an integral centre hub, machined to proper diameter, secured to fan/motor shaft by means of a taper-lock bushing, and statically and dynamically balanced as an assembly.
 - 2.9.4 For belt-drive fans only, AISI 1040 or 1045 hot rolled steel shaft, accurately turned, ground, and polished, and sized for a first critical speed of at least 1.43 times maximum rated speed for fan, and heavy-duty, self-aligning, grease lubricated pillow block type bearings selected for an AFBMA L-50 minimum average life in excess of 200,000 hours at maximum fan RPM and equipped with extended lubrication lines terminated at housing exterior in lubrication fittings, and an adjustable V-belt drive with guard conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical. Drive assembly is to extend through a 2-piece aerodynamically shaped belt fairing welded continuously to both inner cylinder housing fan shaft and bearings, and fan housing.
 - 2.9.5 TEFC foot mounted motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
 - 2.9.6 Steel surfaces of entire fan assembly, excluding fan shaft, are to be thoroughly degreased, deburred, coated with rust-preventive primer, and finished with equipment enamel. Coat fan shaft with a petroleum-based rust protectant.
 - 2.9.7 For fans as scheduled, factory supplied accessories as follows:
 - 2.9.7.1 vibration isolators;
 - 2.9.7.2 torosoidal shaped inlet bell, flanged, drilled and bolted to fan's flanged inlet;
 - 2.9.7.3 galvanized steel wire grid fan inlet/outlet guard(s);
 - 2.9.7.4 inlet/outlet cones, flanged at both ends and drilled to match fan flanges;
 - 2.9.7.5 steel support legs welded to fan flanges;
 - 2.9.7.6 formed steel angle support clips welded to fan housing;
 - 2.9.7.7 factory secured seismic restraint connection hardware.
 - 2.9.8 Manufacturers:
 - 2.9.8.1 Twin City Fan and Blower;
 - 2.9.8.2 Loren Cook Co.;
 - 2.9.8.3 Greenheck Fan Corp.;
 - 2.9.8.4 CML Northern Blower;
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- 2.9.8.5 PennBarry;
- 2.9.8.6 JencoFan;
- 2.9.8.7 Carnes Company Inc.

2.10 CEILING MOUNTED DESTRATIFICATION FANS

- 2.10.1 Northwest Envirofan "Gold Line" white, down-blowing, extra heavy-duty industrial grade, CSA certified direct drive ceiling mount destratification fans in accordance with drawing schedule, each complete with:
 - 2.10.1.1 curved aluminum fan blades secured to a steel hub;
 - 2.10.1.2 permanent magnet, brushless, non-ventilated, heat sink design motor rated for continuous operation at maximum speed in a 55°C (130°F) ambient temperature and capable of modulating fan speed from 0 to 100% without the use of a gearbox or other mechanical means of control, and a factory programmed controller housed in an enclosure independent of motor to minimize starting and braking torques, with a simple diagnostic program and a LED to identify and relay faults in system;
 - 2.10.1.3 250 mm (10") long down rod, a 330 mm (13") long galvanized steel safety chain, and all other required mounting and securing hardware;
 - 2.10.1.4 400 mm (16") long power cord with 3-prong plug, factory pre-wired to motor;
 - 2.10.1.5 "Protecto-Guard" welded wire fan guard sized to suit fan blade size;
 - 2.10.1.6 120 volt variable speed (Off-High-Low) solid-state infinite speed fan controller with stainless steel faceplate designed to mount to a 100 mm (4") outlet box and to control fan groupings as indicated on drawings;
 - 2.10.1.7 factory secured seismic restraint connection hardware.
- 2.10.2 Manufacturers:
 - 2.10.2.1 Northwest Envirofan;
 - 2.10.2.2 Big Ass Fan Co.;
 - 2.10.2.3 Marley Engineered Products "Leading Edge".

2.11 CEILING MOUNTED FANS

- 2.11.1 ULC listed and labelled ceiling mounted centrifugal, AMCA rated and certified (capacity and sound to AMCA Standards 211 and 311), exhaust fans in accordance with drawing schedule, complete with:
 - 2.11.1.1 minimum #20 gauge galvanized steel housing equipped with duct connection collar(s), integral spring loaded aluminum backdraft damper, 12 mm (½") thick acoustic insulation meeting 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, multi-position mounting brackets, and an integral CSA certified electrical receptacle in an outlet box for plug-in connection of fan motor;
 - 2.11.1.2 low RPM, resiliently mounted, direct connected fan wheel and motor assembly with a forward curved, statically and dynamically balanced galvanized steel or calcium carbonate filled polypropylene centrifugal wheel direct connected to a 1-phase motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, and equipped with a length of power cord and plug;
 - 2.11.1.3 for fans as indicated and/or scheduled, a white calcium carbonate exhaust grille;
 - 2.11.1.4 factory supplied accessories in accordance with drawing schedule, as follows:
 - (1) rectangular to round duct transitions;
 - (2) roof cap with backdraft damper and birdscreen;
 - (3) wall cap with backdraft damper and birdscreen.
- 2.11.2 Manufacturers:

- 2.11.2.1 Twin City Fan and Blower;
- 2.11.2.2 Loren Cook Co.;
- 2.11.2.3 Greenheck Fan Corp.;
- 2.11.2.4 CML Northern Blower;
- 2.11.2.5 PennBarry.

2.12 ROOF MOUNTED FILTERED SUPPLY FANS

- 2.12.1 Low profile louvre penthouse type, weatherproof, packaged, centrifugal, factory run tested, roof mounted filtered supply fans as per the drawing schedule.
- 2.12.2 Hood is to be all aluminium welded structural framing and aluminium alloy blade extrusions with mitred corners, removable top cap pitched for water run-off, side access panel, expanded aluminium mesh bird screen, formed filter channels, 25 mm (1") thick glass fibre insulation meeting 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, and an aluminium curb cap.
- 2.12.3 Galvanized steel fan housing of lock seam construction, braced to minimize pulsation and/or vibration and complete with spun, aerodynamically designed inlet cones or venturies, duct adaptor designed to fit over roof curb and permit duct connection before fan is set in place, and a fan inlet screen.
- 2.12.4 Centrifugal, non-overloading aluminum wheel with backward inclined blades continuously welded to rim and back plate, and statically and dynamically balanced as an assembly.
- 2.12.5 Disposable, 50 mm (2") thick glass fibre media filters, ULC Class 2, 20% – 35% efficient, minimum MERV 6 as per ASHRAE 52.2, enclosed in permanent galvanized steel frames with metal retainers on both sides.
- 2.12.6 ANSI 1040 or 1045 cold rolled steel shaft, accurately turned, ground, and polished, and sized for a first critical speed of at least 1.25 times maximum rated speed for fan, and one-piece grease lubricated pillow block type bearings selected for an AFBMA minimum average life in excess of 200,000 hours at maximum catalogue operating speed and equipped with zinc rich paint coated steel bearing supports and a lubrication fitting.
- 2.12.7 Motor mounted on a slide type base and factory pre-wired to a NEMA 4 disconnect switch on unit casing, and adjustable V-belt drive with guard conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical.
- 2.12.8 Prefabricated, minimum 300 mm (12") high heavy-duty aluminum roof mounting curb with factory installed wood nailer, 40 mm (1-½") thick insulation meeting 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, and continuously welded seams.
- 2.12.9 Non-corrosive motorized damper supplied loose for site installation in connecting ductwork, equal to T. A. Morrison TAMCO Series 9000 insulated damper with linkage, end switch, and a Belimo or equal motor with voltage to match fan motor.
- 2.12.10 Factory secured seismic restraint connection hardware.
- 2.12.11 Manufacturers:
 - 2.12.11.1 Twin City Fan and Blower;
 - 2.12.11.2 Loren Cook Co.;
 - 2.12.11.3 Greenheck Fan Corp.;
 - 2.12.11.4 CML Northern Blower;
 - 2.12.11.5 PennBarry;
 - 2.12.11.6 JencoFan;
 - 2.12.11.7 Carnes Company Inc.

2.13 RESIDENTIAL RANGE HOODS

- 2.13.1 Basis of design: Broan Elite E64000 series, model E6436SSLC.
 - 2.13.2 Features:
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- 2.13.2.1 For domestic cooking only.
- 2.13.2.2 914 mm (36 in) wide, 250 mm (10 in) under-cabinet range hood.
- 2.13.2.3 Integrated internal blowers or dedicated external blower capability.
- 2.13.2.4 Dishwasher-safe baffle filters with handles for convenient removal and removable grease drip rail.
- 2.13.2.5 2 LED bulbs (5.5 W each).
- 2.13.2.6 Variable speed control with power on light indicator.
- 2.13.2.7 Designed to duct out of the hood shell in either horizontal and vertical direction with internal blowers. External blowers duct vertically.
- 2.13.2.8 Stainless steel, 22 gauge, type 430, no. 4 brush finish.
- 2.13.2.9 Quiet operation - 2 sones or less at normal speed, sound level no greater than 13.5 sones at high speed.
- 2.13.2.10 Single Blower:
 - (1) Max. blower CFM: 650.
 - (2) 120 VAC, 60 Hz, 5.5 A.

3 EXECUTION

3.1 INSTALLATION OF CENTRIFUGAL FANS

- 3.1.1 Provide centrifugal fans.
- 3.1.2 Secure each base mounted fan in place, level and plumb, on vibration isolation on a concrete housekeeping pad.
- 3.1.3 Secure suspended units in place from structure, level, and plumb, by means of vibration isolation spring hangers, properly sized galvanized steel hanger rods and galvanized structural steel angle or channel trapeze supports.
- 3.1.4 Install explosion-proof units in accordance with classification requirements.
- 3.1.5 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.1.6 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.1.7 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.1.8 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.2 INSTALLATION OF UTILITY FANS

- 3.2.1 Provide utility fans.
 - 3.2.2 Secure each fan in place, level, and plumb, on vibration isolation on a concrete housekeeping pad or base as indicated.
 - 3.2.3 Secure suspended units in place from structure, level, and plumb, by means of vibration isolation spring hangers, properly sized galvanized steel hanger rods, and galvanized structural steel angle or channel trapeze supports.
 - 3.2.4 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
 - 3.2.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
 - 3.2.6 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
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- 3.2.7 Include for a 4 hour on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.3 *INSTALLATION OF CENTRIFUGAL INLINE FANS*

- 3.3.1 Provide inline centrifugal fans.
- 3.3.2 Secure each fan in place from structure with vibration isolation, independent of connecting ductwork and in accordance with fan manufacturer's instructions.
- 3.3.3 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.3.4 Ensure duct connections are made using flexible connection material.
- 3.3.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.3.6 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.3.7 Include for a 4 hour on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.4 *INSTALLATION OF PLENUM FANS*

- 3.4.1 Provide plenum fans in air handling system plenums.
- 3.4.2 Secure fans in place, level, and plumb, on vibration isolation.
- 3.4.3 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.4.4 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.4.5 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.4.6 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.5 *INSTALLATION OF ROOF MOUNTED EXHAUST FANS*

- 3.5.1 Provide roof mounted exhaust fans.
 - 3.5.2 Supply a roof mounting curb with each fan and hand curbs to roofing trade on roof for mounting and flashing into roof construction as part of roofing work. Secure fans in place on curbs.
 - 3.5.3 Install dampers in curb damper tray and secure in place.
 - 3.5.4 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
 - 3.5.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
 - 3.5.6 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
 - 3.5.7 Include for a 4 hour on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.
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3.6 INSTALLATION OF SIDEWALL PROPELLER FANS

- 3.6.1 Provide sidewall propeller fans. Coordinate location(s) and size(s) of wall opening(s) with trade preparing the opening(s).
- 3.6.2 Rigidly secure each fan and accessories in place to structure in accordance with fan manufacturer's instructions.
- 3.6.3 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.6.4 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.6.5 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.7 INSTALLATION OF FRP CENTRIFUGAL FANS

- 3.7.1 Provide FRP centrifugal fans.
- 3.7.2 Secure each base mounted fan in place, level, and plumb, on corrosion resistant vibration isolation on a concrete housekeeping pad.
- 3.7.3 Secure suspended units in place from structure, level and plumb, by means of corrosion resistant vibration isolation spring hangers, properly sized type 316 stainless steel hanger rods and a structural type 316 stainless steel angle, or channel support structure.
- 3.7.4 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.7.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.7.6 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.8 INSTALLATION OF VANEAXIAL FANS

- 3.8.1 Provide vaneaxial fans.
- 3.8.2 Secure each fan in place to or from structure with vibration isolation as indicated, independent of connecting ductwork.
- 3.8.3 Ensure duct connections are made using flexible connection material.
- 3.8.4 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.8.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.8.6 For equipment/system start-up requirements, Refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.8.7 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.9 INSTALLATION OF CEILING DESTRATIFICATION FANS

- 3.9.1 Provide ceiling destratification fans.
 - 3.9.2 Secure each fan in place at the ceiling from structure in accordance with manufacturer's instructions and drawing details. Confirm exact locations prior to roughing-in. Install safety chains and fan blade guards.
 - 3.9.3 Plug each fan motor into an adjacent receptacle.
-

- 3.9.4 Supply a fan speed controller for fans as indicated and hand to electrical trade at site for wall mounting and connection to fan motor controllers. Confirm exact speed controller locations prior to installation, and include for identification of each speed controller.
- 3.9.5 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.9.6 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.9.7 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.9.8 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.10 INSTALLATION OF CEILING FANS

- 3.10.1 Provide ceiling exhaust fans.
- 3.10.2 Secure each ceiling mounted fan housing in place in ceiling space, flush with suspended ceiling.
- 3.10.3 Secure suspended units in place from structure, level, and plumb, by means of vibration isolation spring hangers and galvanized steel hanger rods.
- 3.10.4 Plug fan motors into housing receptacles.
- 3.10.5 Supply exterior wall/roof discharge caps as indicated.
- 3.10.6 Hand roof caps to roof trade for installation and flashing into roof construction as part of roofing work.
- 3.10.7 Install wall caps and secure in place. Caulk perimeter of each wall cap in accordance with caulking requirements specified in Division 07.
- 3.10.8 Connect fan housings and discharges with ductwork.
- 3.10.9 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.10.10 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.11 INSTALLATION OF ROOF MOUNTED FILTERED SUPPLY FANS

- 3.11.1 Provide roof mounted filtered supply fans.
- 3.11.2 Supply a roof mounting curb with each fan and hand curbs to roofing trade on roof for mounting and flashing into roof construction as part of roofing work. Secure fans in place on curbs.
- 3.11.3 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.11.4 Secure duct adaptors in place on curbs on foam tape or other suitable gasket material, and install motorized dampers (supplied loose) in connecting ductwork. Coordinate connection of power from fan starter to damper motor with electrical trade who will make the connection.
- 3.11.5 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.11.6 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.12 INSTALLATION OF RESIDENTIAL RANGE HOODS

- 3.12.1 Provide range hoods where indicated on plans.
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- 3.12.2 Secure each ceiling mounted fan housing in place in ceiling space, flush with millwork uppers.
- 3.12.3 Connect fan housings and discharges with ductwork.
- 3.12.4 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.12.5 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.13 CLOSEOUT ACTIVITIES

- 3.13.1 Include for a 4 hour on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Apparatus bay truck exhaust system.

1.2 ALLOWANCES

- 1.2.1 Engine exhaust system will be carried as a cash allowance in the GC's contract. Refer to Section 01 21 13.

1.3 ADMINISTRATIVE REQUIREMENTS

- 1.3.1 Coordination:
 - 1.3.1.1 General Contractor is to reach out to PCI upon award of contract to start the detailed design for the exhaust system.
- 1.3.2 Sequencing:
 - 1.3.2.1 PCI has identified the longest lead time item for their supplied equipment is 16 weeks on the exhaust fan.
 - 1.3.2.2 PCI prefers to install their system towards the end of construction – needs two weeks for installation.

1.4 SUBMITTALS

- 1.4.1 Submit shop drawings/product data sheets for equipment and accessories. Include following:
 - 1.4.1.1 Fan performance curve at specified operating point with flow, static pressure and horsepower clearly plotted.
 - 1.4.1.2 Sound power data that conforms to specified levels.
 - 1.4.1.3 Product data sheets for all accessories.
 - 1.4.1.4 Product data sheet for fan motor.
 - 1.4.1.5 Power and control wiring schematic.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Submit with delivery of each unit a copy of the factory inspection report, and include a copy of each report with O&M Manual project close-out data.
- 1.5.2 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this section.
- 1.5.3 Training attendance records.

1.6 MOCK-UPS

- 1.6.1 Provide a mock-up installation of one tailpipe exhaust system hose balancer assembly at site after:
 - 1.6.1.1 shop drawings and product data sheets have obtained "Reviewed" status;
 - 1.6.1.2 main duct has been installed with branch take-offs;
 - 1.6.1.3 representative vehicle can be safely brought into facility;
 - 1.6.1.4 working hoist, certified for safe operation to lift a vehicle to full design height is in operation.
 - 1.6.2 Mock-up is to specifically establish and confirm:
 - 1.6.2.1 length of exhaust hose;
 - 1.6.2.2 location of hose connection to duct;
 - 1.6.2.3 location of balancer;
 - 1.6.2.4 hose length before and after elbow;
 - 1.6.2.5 hose location relative to vehicle exhaust pipe;
 - 1.6.2.6 hose nozzle suitability for each type of vehicle tailpipe.
-

- 1.6.3 Incorporate Owner's and Consultant's comments into mock-up until an acceptable prototype has been established. Resubmit shop drawings/product data to reflect incorporated mock-up changes.
- 1.6.4 Do not install remainder of systems until mock-up has been accepted.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Pollution Control Installations Inc. (PCI)
dave@pci-inc.ca
- 2.1.2 Substitutions: None. Owner's standard.

2.2 TAILPIPE EXHAUST SYSTEM COMPONENTS

- 2.2.1 Chambers will be located on the passenger side of the trucks, approx. 65 ft long. Each chamber needs two 6 in connections about 17 ft from the end of each chamber – that route to the exhaust fan location.
- 2.2.2 Exhaust Fan.
- 2.2.3 Factory secured seismic restraint connection hardware for all equipment requiring seismic restraint.
- 2.2.4 Wall mounted Control panel.
- 2.2.5 Associated duct work to interconnect components.

2.3 ELECTRICAL

- 2.3.1 Provide power (wiring) to be brought to the location of the control panel (600 V 3 phase).
- 2.3.2 Provide power (wiring) to be brought to the location of the exhaust fan (600 V 3 phase).

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Stack for the exhaust fan - wall penetration is GC responsibility.
 - 3.1.2 Provide a complete tailpipe exhaust system. Conform to requirements of ANSI/NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids.
 - 3.1.3 Secure exhaust fan in place on vibration isolation on a roof mounted base provided as part of the work of Division 07. Provide weather-proof flexible connection material in suction duct connection to fan, and a galvanized steel protective rain hood over flexible connection. Terminate fan discharge with a rain hood. Refer to drawing detail.
 - 3.1.4 Provide exhaust extractor assemblies with balancers and hoses where shown but confirm exact locations prior to installation. Secure to structural steel and provide additional structural steel members as required for support. Refer to mock-up requirements specified in Part 1 of this section.
 - 3.1.5 Install and pressure test ductwork in accordance with requirements specified in Section 23 30 00 – HVAC Air Distribution. Ductwork is to be air and water-tight at system operating pressure. Slope all ductwork to drain points. Provide drain connections at drain points and provide type DWV soldered copper drain piping from drain points to floor drains.
 - 3.1.6 Install dampers in ductwork generally where shown but ensure dampers are accessible and cannot move or rattle.
-

- 3.1.7 Install pressure transducer with 2 sensing points in duct main to measure differential pressure.
- 3.1.8 Connect balancer switches to damper motors to energize damper motor and open damper when hose is pulled down, and to close damper when hose is retracted. Connect pressure transducer to variable frequency drive to start exhaust fans as required. Install control wiring in conduit in accordance with system manufacturer's certified wiring schematic and electrical work wiring requirements.
- 3.1.9 Brace and secure system equipment in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.

3.2 SYSTEM STARTUP

- 3.2.1 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.2.2 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.3 CLOSEOUT ACTIVITIES

- 3.3.1 Include for a 1/2 day on-site operation demonstration and training session. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Electric water boilers.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 23 21 00 – Hydronic Piping and Pumps.
- 1.2.2 Section 23 83 16.16 – In-Floor Radiant-Heating Hydronic Piping.

1.3 REFERENCES

- 1.3.1 ANSI/ASME Boiler and Pressure Vessel Code, Section IV for low pressure and Section I for high pressure.
- 1.3.2 CSA B51, Boiler, Pressure Vessel, And Pressure Piping Code, and Ontario Technical Standards and Safety Act, 2000, Boilers and Pressure Vessels O.Reg. 220/1.
- 1.3.3 Electrical equipment and wiring to conform to Canadian Electric Code.
- 1.3.4 Boiler package to bear ULC, or CSA label.

1.4 SUBMITTALS

- 1.4.1 Submit shop drawings/product data sheets for boilers, including accessories, and all required wiring schematics in accordance with Section 01 33 00.
- 1.4.2 Indicate:
 - 1.4.2.1 Model number.
 - 1.4.2.2 Guaranteed input and output rating performance.
 - 1.4.2.3 Outline dimensions.
 - 1.4.2.4 Power requirements.
 - 1.4.2.5 Water inlet and outlet connection details.
 - 1.4.2.6 Loading points and weights.
 - 1.4.2.7 Control panel layouts and wiring diagrams.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Submit with delivery of boiler(s) a copy of factory inspection and test report for each boiler, and include a copy of each report with O&M Manual project closeout data.
- 1.5.2 Submit a site inspection and boiler start-up report from boiler manufacturer's representative as specified in Part 3 of this section.
- 1.5.3 Submit signed copies of a manufacturer's non-prorated 10 year extended warranty for cast aluminium heat exchanger against corrosion, thermal stress, mechanical defects, and workmanship, and 2 year extended warranty for all other boiler components.
- 1.5.4 Training attendance records.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- 1.6.1 Supply a complete spare charge of calcium silicate chips for each acid neutralizing tank.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Precision Boilers.
 - 2.1.2 Approved equivalent.
-

- 2.1.3 Substitutions shall indicate any deviations from this section and shall state price additions or deductions for substitution.

2.2 ELECTRIC HOT WATER BOILERS

- 2.2.1 Furnish and install as shown on the plans electric hot water boiler(s), fabricated per these specifications, including all accessories and construction features as described herein. Boilers shall be completely factory assembled and pre-tested prior to shipment. Boilers shall be UL labeled and comply with CSD-1. Boiler shall include an ASME Section IV pressure vessel which has been fabricated under inspection by an authorized inspector holding a National Board commission and subsequently stamped and National Board registered.

2.3 RATINGS

- 2.3.1 Boilers shall each be PRECISION Compac, designed and fabricated for a balanced 3-phase, 3-wire, delta load at 575 volts, 3-phase, 60 Hertz.

2.4 PRESSURE VESSEL

- 2.4.1 The pressure vessel and all trim shall be as set forth in the ASME Code, including ASME "HV" stamped safety relief valve sized as required. The vessel shall be provided with a threaded 3" (4" flanged) inlet and a threaded 3" (4" flanged) outlet, plus safety valve and drain nozzle as required. The pressure vessel shall be housed in a 16-gauge steel enclosure allowing 4 inches of insulation space around the vessel and filled with 4 inches of 3/4 pound-density fiberglass insulation. The electric panel and vessel shall be mounted on a common, structural steel base.

2.5 INTERNAL POWER DISTRIBUTION

- 2.5.1 The power distribution shall be through cable connection to mechanical lugs. Power shall be fed through current limiting fuses to magnetic contactors, and then to the heating element circuits. Contactors shall be 3-pole magnetic contactors tested by UL for 500,000 cycles at full load. The coil voltage shall be 120 volts. Internal wiring shall be in accordance with NEC/NFPA Article 424-G and UL Subject 834.

2.6 HEATING ELEMENTS

- 2.6.1 Elements shall be individually mounted in steel flanges. The flange size shall not exceed 2-1/2 inches square, with a maximum of three single bend U-shaped element blades per flange. Element sheath material shall be Incoloy; element watt density shall be 75 WSI.

2.7 CONTROLS

- 2.7.1 The control circuit shall be 120 volt single-phase, one side grounded. Control voltage shall be provided by an integral control circuit transformer, fused on both legs of the primary, with a control circuit fuse on the ungrounded leg of the secondary. The controls shall include an ON/OFF switch, temperature controller, solid state step control, indicator lights and manual limiting switches for each stage of heating, a low water cut-off with test/reset buttons, and one auto reset and one manual reset high limit temperature switch.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Provide electric boilers.
-

- 3.1.2 Move boilers into position, remove casters, and secure each boiler in place, level, and plumb, on neoprene-steel-neoprene vibration isolation pads on a concrete housekeeping pad.
- 3.1.3 Anchor each boiler and concrete base in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems. Provide flexible connections in piping connections to each boiler.
- 3.1.4 Connect each boiler with piping and flue.
- 3.1.5 Install condensate acid neutralizers adjacent to boilers and connect with piping from boilers to neutralizers and from neutralizers to drain in accordance with manufacturer's directions and drawing requirements.
- 3.1.6 Install control components shipped loose for each boiler, including low water cut-offs, relief valve, and flow switch. Unless otherwise instructed, follow manufacturer's installation instructions. Provide pressure gauges and thermometers in boiler water supply and return piping connections.
- 3.1.7 Wall mount lead/lag control panel where shown but confirm exact location prior to installation.
- 3.1.8 Perform required control wiring in conduit to connect control components. Follow boiler manufacturer's control wiring schematics and conduit and conductor installation requirements specified as part of electrical work.
- 3.1.9 When boiler plant installation is substantially complete, but prior to start-up, and prior to flushing and cleaning heating piping system, inspect each boiler and remove visible dirt, oil, and debris, then cooperate with the boiler boil-out chemical supplier to ensure proper boil-out procedures are followed.

3.2 SYSTEM STARTUP

- 3.2.1 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.2.2 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.3 CLOSEOUT ACTIVITIES

- 3.3.1 Include for a one day on-site boiler plant operation demonstration and training session. Training is to be a full review of all components including but not limited to a full boiler internal inspection, construction details, burner operation, maintenance, flame characteristics, and adjustments, gas train maintenance, boiler normal operation, abnormal events, normal shut-down, emergency shut-down, and setting up controls.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Energy Recovery Ventilators

1.2 SUBMITTALS

- 1.2.1 Submit shop drawings/product data sheets for heat recovery ventilators, including accessories, and all required power and control wiring schematics.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Submit with delivery of each unit a copy of the factory inspection report, and include a copy of each report with O&M Manual project close-out data.
- 1.3.2 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this section.
- 1.3.3 Submit a signed extended warranty direct from manufacturer to Owner covering the energy recovery wheel from material and workmanship defects for an additional 4 years after Contract warranty expires.
- 1.3.4 Training attendance records.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- 1.4.1 Supply a spare filter set for each ventilator and store at site where directed prior to Substantial Performance of the Work.

1.5 COORDINATION

- 1.5.1 Supply reviewed copies of ventilator/curb assembly shop drawings or product data to trade who will cut roof openings for ventilators, and ensure openings are properly located.

1.6 QUALITY ASSURANCE

- 1.6.1 Energy recovery ventilator manufacturers are to be current members of Air Movement and Control Association International Inc. (AMCA), and fans are to be rated (capacity and sound performance) and certified in accordance with requirements of following standards:
 - 1.6.1.1 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
 - 1.6.1.2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
 - 1.6.1.3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;
 - 1.6.1.4 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;
 - 1.6.1.5 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans;
 - 1.6.1.6 AHRI Standard 1060, Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment;
 - 1.6.1.7 ASHRAE 84, Method of Testing Air-to-Air Heat/Energy Exchangers;
 - 1.6.1.8 UL 1812, Ducted Heat Recovery Ventilators;
 - 1.6.1.9 CSA or ETL certification for all electrical components.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Greenheck Fan Corp.;
 - 2.1.2 Venmar CES Inc.;
 - 2.1.3 Summerraire Manufacturing;
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- 2.1.4 Carrier Corp.
- 2.1.5 Lifebreath
- 2.1.6 Reversomatic Manufacturing Ltd.
- 2.1.7 RenewAire
- 2.1.8 Panasonic

2.2 ENERGY RECOVERY VENTILATORS

- 2.2.1 Factory assembled, internally wired heat recovery ventilators in accordance with drawing schedule, and with AHRI certified energy recovery ratings.
 - 2.2.2 Interior Unit Casings and Frame: Internal frame type casing constructed of heavy-gauge G90 galvanized sheet steel with interior surfaces lined with 25 mm (1") thick, 24 kg/m³ (1-½ lb/ft³) density coated glass fibre duct lining material meeting 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, Surface Burning Characteristics of Building Materials and Assemblies, and installed with all exposed edges tucked under flanges. Additional features and requirements as follows:
 - 2.2.2.1 casings complete with factory sealed metal-to-metal joints, a solid integral base with up-turned lips around bottom openings, separate openings and knock-outs for power and control wiring conduit connections, top panels, where joints are required, are to be equipped with a standing seam, and all metal exposed to weather is to be factory cleaned, primed, and finished with baked enamel;
 - 2.2.2.2 removable gasketed panels or hinged gasketed access doors provided for access to all interior components;
 - 2.2.2.3 stainless steel drain pan pitched for positive drainage and equipped with captive condensate drain pipe connection.
 - 2.2.3 Exterior Unit Casings and Frame: Internal frame type double wall weather-proof casing constructed of heavy-gauge G90 galvanized sheet steel, minimum 18 gauge for exterior panels, minimum 24 gauge with interior panels, with 25 mm (1") thick, 24 kg/m³ (1-½ lb/ft³) density coated glass fibre insulation material meeting 25/50 flame spread/smoke developed ratings when tested in accordance with CAN/ULC S102, Surface Burning Characteristics of Building Materials and Assemblies and secured in place between panels such that it will not sag. Additional features and requirements as follows:
 - 2.2.3.1 weather-tight casings, complete with factory sealed metal-to-metal joints, a solid integral base with up-turned lips around bottom openings, and separate openings and knock-outs for power and control wiring conduit connections;
 - 2.2.3.2 removable gasketed panels or hinged gasketed access doors provided for access to all interior components;
 - 2.2.3.3 stainless steel drain pan pitched for positive drainage and equipped with captive condensate drain pipe connection;
 - 2.2.3.4 downturned design air intake and exhaust hoods constructed and factory finished as for casings, each with an "A" water penetration classification rating up to 200 mm/hr (8"/hr) rainfall at 22 m/s (50 mph) when tested in accordance with AMCA Standard L-500, and washable aluminium mesh pre-filters;
 - 2.2.3.5 minimum 200 mm (8") high, full perimeter, galvanized steel insulated roof curb supplied loose with each unit for field assembly, consisting of die-formed sections with gasket material for installation between curb and unit base.
 - 2.2.4 Enthalpy type energy recovery wheel for both sensible and latent heat recovery, designed to ensure laminar air flow, with energy transfer ratings in accordance with ASHRAE 84 and AHRI certified to AHRI 1060, designed to transfer moisture entirely in vapour phase, consisting of removable segments for larger wheels, and complete with:
 - 2.2.4.1 silica gel desiccant permanently bonded to lightweight polymer media mounted in a stainless steel rotor;
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- 2.2.4.2 bearings selected for a minimum L-10 life in excess of 400,000 hours;
 - 2.2.4.3 high-strength urethane drive belt factory installed in a pre-stretched state, and a motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical;
 - 2.2.4.4 frost control protection with an electric pre-heater.
 - 2.2.5 Enthalpy core shall be of total enthalpy and shall be removable from the cabinet. The core media shall be a corrugated fiber membrane in a galvanized steel framework and can be removable for servicing. Performance criteria are to be as specified in AHRI Standard 1060. Core shall be complete with:
 - 2.2.5.1 a galvanized steel framework (designed to produce laminar air flow through the core)
 - 2.2.5.2 frost control protection in the form of timed exhaust. Control system shall include an outdoor air thermostat to initiate frost control sequence.
 - 2.2.5.3 a five-year warranty.
 - 2.2.6 Dampers: Backdraft dampers for the discharge air streams shall be factory installed.
 - 2.2.7 Disposable glass fibre media filters, ULC listed Class 2, side removable, 50 mm (2") thick, pleated, MERV 8 rating, factory or field installed in a die-formed galvanized steel filter rack at air intake opening.
 - 2.2.8 Centrifugal, draw-through within reference to the energy recovery wheel, double width and inlet exhaust and supply fans with forward curved blades, belt driven or direct driven as indicated, statically and dynamically balanced, mounted to unit base with neoprene vibration isolation, and equipped with:
 - 2.2.8.1 ground and polished steel fan shafts mounted in permanently lubricated sealed ball bearing pillow blocks selected for a minimum L-10 life in excess of 200,00 hours at maximum operating speed;
 - 2.2.8.2 motors and where indicated, belt drives conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
 - 2.2.9 Each ventilator is to be equipped with a sealed and factory pre-wired control box containing terminal blocks for power and control wiring connections, integral door interlocking disconnect switch, an overload protected contactor for each motor, fuses, and 24 VAC secondary control transformer.
 - 2.2.10 Control system in accordance with drawing control schematic/sequence, and to include if indicated, all required hardware and circuitry for connection into building automation system using protocol as specified with the system.
 - 2.2.11 Factory supplied, mounted, and wired variable frequency drives conforming to requirements of Section 20 05 13.13 – Variable Frequency Drives for Mechanical Equipment.
 - 2.2.12 Auxiliary coil(s) rated and certified in accordance with AHRI Standard 410, Forced-Circulation Air-Cooling and Air-Heating Coils, drainable, designed and constructed to meet requirements of the ASME Code Category "H" as a registered fitting, and complete with a CRN. Coil data, performance, and specific features not specified below are to be in accordance with drawing detail. Each coil is to be complete with:
 - 2.2.12.1 slide in/slide out galvanized steel mounting framework;
 - 2.2.12.2 16 mm (5/8") O.D. seamless copper tubes with 1.24 mm (1/16") thick tube walls;
 - 2.2.12.3 aluminum fins mechanically bonded to tubes;
 - 2.2.12.4 welded Schedule 40 ASTM A53 seamless steel pipe headers with same end supply and return connections, and 9.5 mm (3/8") tappings for an air vent and a drain valve;
 - 2.2.12.5 flanged #14 gauge type 304 stainless steel casing designed to drain off standing water;
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- 2.2.12.6 for cooling coils only, an insulated stainless steel drain pan sloped for positive drainage from all points and equipped with a captive drain pipe connection coupling.
- 2.2.13 Factory secured seismic restraint connection hardware.
- 2.2.14 Factory assembled, internally wired heat recovery ventilators in accordance with drawing schedule, and with AHRI certified energy recovery ratings.
- 2.2.15 Casing: Formed single wall insulated metal cabinet, fabricated to permit access to internal components for maintenance. Access door shall provide easy access to blowers, core, and filters. Access door shall be hinged with airtight closed cell foam gaskets.
- 2.2.16 No condensate drain pans or drains shall be allowed and unit shall be capable of operating in both winter and summer conditions without generating condensate.
- 2.2.17 Heat Exchanger Core: Fixed-plate cross-flow construction, with no moving parts. Core shall be designed and constructed to permit cleaning and removal for servicing.
- 2.2.18 Motor: High efficiency, variable speed motor to allow for multiple fan speeds
- 2.2.19 Filters: MERV-8 rated, spun polyester, disposable filter in both airstreams
- 2.2.20 Control system in accordance with drawing control schematic/sequence, The unit shall be capable of operating continuously or intermittently at the low airflow (adj.) setting with the ability to go temporarily to the high airflow (adj.).
- 2.2.21 Frost Control: Core shall have a means of preventing the buildup of excess frost within unit

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Provide heat recovery ventilators.
- 3.1.2 For suspended units, provide galvanized steel mounting brackets with vibration isolators and suspend each unit, level, and plumb, by means of hanger rods. Provide supplementary support steel as required.
- 3.1.3 Secure each indoor floor mounted ventilator in place, level and plumb, on neoprene-steel-neoprene vibration isolation pads on a concrete housekeeping pad.
- 3.1.4 Supply an assembled roof curb for each outdoor roof mounted ventilator and hand to roof trade at site on roof. Carefully locate and size roof openings. Provide gasket material supplied with curb on perimeter of curb and secure ventilator in place.
- 3.1.5 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.1.6 For ventilators with auxiliary hydronic coils, connect each coil to system valved hydronic piping with flexible connectors in accordance with Section 23 21 00 – Hydronic Piping and Pumps. Provide trapped condensate drainage piping connection to cooling coil condensate drain pans in accordance with Section 22 13 00 – Facility Sanitary Sewerage.
- 3.1.7 Coordinate power wiring connection and provision of a disconnect switch for each ventilator in accordance with electrical work Specification where power wiring is specified.
- 3.1.8 Use factory supplied mounting flange to mount the unit per manufacturer's installation manuals to a structurally suitable surface. Provide service clearances as indicated in manufacturer's installation manual.

3.2 SYSTEM STARTUP

- 3.2.1 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

- 3.2.2 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.3 CLOSEOUT ACTIVITIES

- 3.3.1 Include for a ½ day on-site heat recovery ventilator operation demonstration and training session. Training is to be a full review of all components including, but not limited to, a full heat recovery ventilator internal inspection, construction details, operation, maintenance, abnormal events, and setting up controls.

END OF SECTION

1 GENERAL

1.1 RELATED REQUIREMENTS

- 1.1.1 Section 23 23 00 – Refrigerant Piping.

1.2 SUBMITTALS

- 1.2.1 Submit shop drawings/product data sheets, complete with control components, and piping and wiring schematics.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Submit a start-up and certification letter from equipment supplier as specified in Part 3 of this section.
- 1.3.2 Prepare and submit a schematic layout of refrigerant piping showing all piping components required for satisfactory operation and maintenance of the system(s), including but not limited to pipe sizes, charging valve, isolating valves, sight glasses, strainers, driers, traps, etc. Schematic diagram must be reviewed with and approved by air conditioning equipment supplier prior to submittal to the Consultant.

1.4 QUALITY ASSURANCE

- 1.4.1 Split system air conditioning equipment and installation of equipment are to be in accordance with requirements of following:
- 1.4.1.1 all applicable Provincial Codes and Standards;
 - 1.4.1.2 ANSI/AHRI Standard 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- 1.4.2 Split system air conditioning system installation tradesmen are to be journeyman refrigeration mechanics.

2 PRODUCTS

2.1 SPLIT SYSTEM AIR CONDITIONING EQUIPMENT

- 2.1.1 Factory assembled and tested, package type equipment consisting of an indoor evaporator unit and an exterior condensing unit in accordance with drawing schedule, CSA or ETL listed and labelled, AHRI rated and certified and with a minimum system efficiency of 13 SEER.
- 2.1.2 Wall mounting evaporator assembly consisting of a white moulded high-strength plastic cabinet with front access panel, a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction and which closes when fan operation is stopped, motorized vertical vanes controlled remotely, and a mounting plate supplied loose. Evaporator complete with:
- 2.1.2.1 double inlet, forward curve fan(s) direct driven by a single 4-speed motor;
 - 2.1.2.2 removable and washable return air filter;
 - 2.1.2.3 factory pressure tested multi-angled coil of non-ferrous construction with aluminium fins, copper tubes with silver alloy solder joints, and an insulated condensate drain pan sloped to a drain connection for positive drainage.
- 2.1.3 Factory run tested, weatherproof condensing unit equipped with a control board to interface with indoor unit and perform all necessary operation functions. Pre-charge unit with R-410a refrigerant for a minimum of 21 m (70') of refrigerant tubing. Unit is to be capable of operation at -18°C (0°F) without additional low ambient controls, and capable of a height difference between condensing unit and evaporator of 30 m (100'). Each condensing unit complete with:

- 2.1.3.1 galvanized steel plate cabinet with an electrostatically applied thermally fused polyester powder finish, and an ABS plastic fan grille;
- 2.1.3.2 draw-through direct driven balanced fan with horizontal air discharge, mounted in front of coil, arranged to pull air across coil, and equipped with a raised fan guard;
- 2.1.3.3 "L" shaped coil with copper tubes and aluminium fins, factory pressure tested, complete with an integral metal guard and refrigerant flow controlled by a linear expansion valve metering orifice controlled by a microprocessor controlled step motor;
- 2.1.3.4 vibration isolated DC rotary compressor driven by an inverter circuit to dynamically control compressor speed to match room load, complete with an accumulator, high pressure safety switch, and circuitry to permit a minimal amount of current to be applied to motor to maintain enough heat during off cycle to prevent liquid from accumulating.
- 2.1.4 System controls consisting of a microprocessor in each indoor and outdoor unit, and an indoor wall mounted controller site connected to indoor evaporator unit. System is to be capable of automatic restart after power interruption, and have self-diagnostics ability and indication of total compressor run time, and following:
 - 2.1.4.1 Indoor unit microprocessor is capable of monitoring return air temperature and evaporator coil temperature, receiving and processing commands from wall mounted controller, providing emergency operation, and controlling outdoor unit through its microprocessor and interface board;
 - 2.1.4.2 controller is complete with an integral temperature sensor, able to perform input and output functions necessary to operate system, and equipped with following:
 - (1) large DOT liquid crystal display to indicate diagnostic codes for both indoor and outdoor units, compressor run time, a weekly timer with up to 8 pattern settings per day, set temperature, room temperature, refrigerant piping temperatures, compressor operating conditions, and linear expansion valve opening pulses, sub-cooling and discharge super heat;
 - (2) On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Dry/Fan mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Vane Position selector, a Louvre Swing button, a Ventilation button, a Test Run button, and a Check Mode button.
- 2.1.5 Suitable anchoring connection hardware factory installed on equipment to suit requirements of Section 20 05 48.16 – Seismic Controls for Mechanical Systems.

2.2 MANUFACTURERS

- 2.2.1 Mitsubishi Electric Sales Canada Inc.;
- 2.2.2 LG Electronics Canada Inc.;
- 2.2.3 Panasonic Canada Inc.;
- 2.2.4 Fujitsu General America Inc.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Provide split system air conditioning equipment consisting of an exterior condensing unit and an indoor evaporator.
 - 3.1.2 Secure condensing unit in place, level and plumb, on vibration isolation pads on a concrete housekeeping pad.
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- 3.1.3 Secure condensing unit in place, level and plumb, on vibration isolation pads on pressure treated wooden sleepers as indicated.
- 3.1.4 Anchor equipment in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems. Provide flexible connections in all piping connections to equipment.
- 3.1.5 Mount indoor evaporator unit. Confirm exact location prior to roughing-in.
- 3.1.6 Connect condensing unit and indoor evaporator with refrigerant piping in accordance with piping shop drawing schematic. Refer to Section 23 23 00 – Refrigerant Piping. Provide any required additional refrigerant.
- 3.1.7 Install loose control components and perform required control wiring (except building automation system connections) between condensing unit and evaporator in conduit in accordance with manufacturer's control wiring schematic and wiring standards of electrical work.

3.2 SYSTEM STARTUP

- 3.2.1 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.2.2 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.3 CLOSEOUT ACTIVITIES

- 3.3.1 Include for 4 hours of on-site operation demonstration and training session. Training is to be a full review of all components including, but not limited to, a full operation and maintenance demonstration, with control set-up and abnormal events.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Variable Refrigerant Flow (VRF) air conditioning system consisting of one or more outdoor compressor units and multiple indoor fan coil units.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 23 23 00 – Refrigerant Piping.

1.3 SUBMITTALS

- 1.3.1 Submit shop drawings/product data sheets, complete with control components, and piping and wiring schematics.
- 1.3.2 Prepare and submit a schematic layout of refrigerant piping showing all piping components required for satisfactory operation and maintenance of the system(s), including but not limited to pipe sizes, charging valve, CSA B52 refrigerant charge analysis, isolating valves, sight glasses, strainers, driers, traps, etc. Schematic diagram must be reviewed with and approved by air conditioning equipment supplier prior to submittal to the Consultant.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Submit a start-up and certification letter from equipment supplier as specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

- 1.5.1 Split system air conditioning equipment and installation of equipment are to be in accordance with requirements of following:
 - 1.5.1.1 All applicable provincial codes and standards;
 - 1.5.1.2 ANSI/AHRI Standard 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - 1.5.1.3 ANSI/AHRI Standard 1230. Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment
- 1.5.2 Split system air conditioning system installation tradesmen are to be journeyman refrigeration mechanics.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 VRF system shall automatically vary the target evaporating and condensing temperatures based on building load and weather conditions to increase part load efficiency (Variable Refrigerant Temperature). The condensing unit shall also feature customizable operating modes which allows for the manual setting of target evaporating and condensing temperatures.
- 2.1.2 System shall permit simultaneous heating and cooling of each indoor unit. Multiple indoor units connected to a single branch selector port shall operate in the same mode (heating or cooling), similar to a two pipe heat pump system. Refer to article “central controls” in this section for any central controller and/or mode switchover sequence.

2.2 MANUFACTURERS

- 2.2.1 Daikin Industries Ltd.;
 - 2.2.2 Mitsubishi Electric Sales Canada Inc.;
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2.2.3 LG Canada.

2.3 VRF FAN COILS

2.3.1 VRF fan coils shall monitor and maintain the unit superheat (cooling mode) or subcooling (heating mode) using a computerized PID control. Internal unit components shall be factory wired and piped, and complete with electronic proportional expansion valve, flare connections, condensate drain pan, self-diagnostics, and auto-restart function.

2.3.2 Wall Mounted Unit

2.3.2.1 Wall mounted fan coil unit for installation onto a wall within a conditioned space. A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment.

2.3.2.2 The indoor unit's sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 1 m (3.3 feet) below and 1 m (3.3 feet) away from the unit.

2.3.2.3 The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing.

2.3.2.4 The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.

2.3.2.5 The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

2.3.2.6 The fan type shall be direct-drive cross-flow with statically and dynamically balanced impeller with high and low fan speeds available.

2.3.2.7 Units shall be provided with a loose field installed condensate pump.

2.3.3 Ceiling Mounted Ducted Unit

2.3.3.1 Ceiling mounted ducted fan coil unit with variable speed direct drive DC type fan and auto CFM adjustment at commissioning. Casing shall be constructed of galvanized steel. Configuration shall be horizontal discharge air with horizontal return air, with a maximum height of 9-5/8" and be designed to fit in tight ceiling plenums.

2.3.3.2 The indoor unit's sound pressure shall range from 28 dB(A) to 36 dB(A) at low speed measured 5 feet below the ducted unit.

2.3.3.3 The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 25" of lift from the center of the drain outlet and have a built-in safety shutoff and alarm.

2.3.3.4 The fan shall have a variable speed direct drive DC motor with statically and dynamically balanced impeller with 3 user-selectable fan speeds. The automatic fan speed mode shall allow the fan to vary between 5 speeds based on space load. The unit shall have logic for automatically adjusting external static pressure settings of the fan motor (selectable during commissioning).

2.3.3.5 The unit shall ship from the factory in a rear return configuration and shall be field convertible to a bottom return configuration.

2.4 AIR COOLED CONDENSING UNIT

2.4.1 The condensing unit shall be factory assembled in North America and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of Daikin inverter scroll compressors, motors, fans, heat exchanger, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver (heat recovery only) and suction accumulator.

2.4.2 The system will automatically restart operation after a power failure and will not cause any settings to be lost.

2.4.3 The unit shall incorporate an auto-charging feature to ensure proper refrigerant charge.

- 2.4.4 The following safety devices shall be included on the condensing unit: high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter, and anti-recycling timers.
 - 2.4.5 The inverter scroll compressors shall be high efficiency reluctance DC (digitally commutating), hermetically sealed, variable speed type. Temperatures and pressures shall be read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value. Non inverter-driven compressors shall not be accepted.
 - 2.4.6 Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. Upon complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
 - 2.4.7 The compressors' motors shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
 - 2.4.8 Inverter board shall be refrigerant-cooled to prevent inefficient and unstable operation that can result from air-cooled inverter boards due to varying ambient conditions.
 - 2.4.9 The compressor shall be internally isolated to avoid the transmission of vibration.
 - 2.4.10 In the case of multiple condenser modules, operation hours of the compressors shall be balanced by means of the Duty Cycling Function
 - 2.4.11 The fan motor shall have inherent protection and permanently lubricated bearings. The motor shall be provided with a fan guard to prevent contact with moving parts. The condensing unit shall consist of one or more propeller type, direct-drive 350 W or 750 W fan motors that have multiple speed operation via a DC (digitally commutating) inverter. Motors shall be capable of delivering design air at high external static pressures up to 0.32 in WG (factory set as standard at 0.12 in. WG) to accommodate field applied condensing unit discharge ductwork.
 - 2.4.12 Night setback control for low noise operation shall automatically limit the maximum speed of the fan motor.
 - 2.4.13 The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tubes with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
 - 2.4.14 The fins are to be covered with an anti-corrosion hydrophilic blue coating as standard with a salt spray test rating of 1000hr (ASTM B117 & Blister Rating:10), Acetic acid salt spray test of 500hr (ASTM G85 and Blister Rating:10).
 - 2.4.15 The outdoor unit shall be capable of heating operation down to -13°F ambient temperature. Tested factory data on heating capacity and efficiency shall be available. Continuous heating shall be provided during defrost mode for multi-module systems.
 - 2.4.16 The outdoor unit shall be capable of cooling operation down to +23°F without any additional low ambient controls.
 - 2.4.17 The outdoor coil shall have a three-circuit heat exchanger design. The lower part of the coil shall be used for inverter cooling, enhancing defrost during heating operation.
 - 2.4.18 The system shall have a factory standard technical cooling option to allow simultaneous heating and cooling down to -4°F. Manufacturers that cannot guarantee simultaneous heating and cooling down to -4°F, even when the system is cooling-dominant, shall provide separate systems for zones requiring year-round cooling.
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2.5 WATER COOLED CONDENSING UNIT

- 2.5.1 The condenser heat exchanger shall be a stainless brazed plate type designed for closed loop/dry cooler applications.
- 2.5.2 Heat generated by the compressor, inverter board, and any other components shall be rejected to the refrigerant loop via an internal DX heat exchanger.
- 2.5.3 Each condensing unit water-loop shall also be installed with a field supplied flow switches wired into each condensing unit module to ensure flow prior to energization of unit.
- 2.5.4 Condensing units shall be supported according to manufacturers requirements.

2.6 BRANCH SELECTOR BOX

- 2.6.1 Selector box cabinets shall have a galvanized steel plate casing and shall house multiple electronic expansion valves and a sub-cooling loop. The unit shall contain sound absorption thermal insulating material made of flame and heat resistant foamed polyethylene.
- 2.6.2 Branch selector boxes shall not require drain pan and drain connections. Manufacturers with branch selector boxes requiring secondary drain pans and drain connections shall coordinate with the installing contractor at no extra cost to the owner.
- 2.6.3 Manufacturers with branch selector box sizes, arrangements, or locations that differ from what is specified shall make the necessary arrangements to ensure their alternative branch selector boxes both fit in the space and that CSA B52 compliance is still met (CSA compliance shall include the life-safety maximum refrigerant charge allowance).
- 2.6.4 Manufacturers shall provide sound data for all branch selector boxes. If sound data is unavailable or exceeds the values below, or if branch boxes make use of solenoid valves instead of electronic expansion valves, necessary precautions shall be taken. Precautions shall include the supply and install of sound blankets, or the relocation of branch boxes away from the occupied spaces, or extra insulation to the ceilings and walls around the branch selector boxes, all at no extra cost to the owner.

2.7 LOCAL CONTROLS

- 2.7.1 Fan coil units shall be supplied with individual zone controllers.
- 2.7.2 Zone controllers shall be hard wired by installing contractor.
- 2.7.3 Controllers shall be able to function as follows:
 - 2.7.3.1 The controller shall have single and dual setpoints for occupied periods, and independent setback setpoints for unoccupied periods.
 - 2.7.3.2 The controller shall have the ability to digitally prohibit individual buttons and functions, including custom mode selection.
 - 2.7.3.3 The controller shall have a self diagnosis function that constantly monitors the system for malfunctions.
 - 2.7.3.4 The controller shall be equipped with a thermostat sensor.
 - 2.7.3.5 Controller shall have built-in 7 day, weekday plus Saturday Sunday (5+1+1), weekday plus weekend (5+2) and everyday (1) scheduler.

2.8 CENTRAL CONTROLS

- 2.8.1 Provide an advanced multi-zone controller for installation in a common area as shown on the plans. The controller shall have a display with the following screen views and functionalities:
 - 2.8.1.1 Central control of set points, schedules, fan speeds, heat/cool mode, and of setback (override) temperature settings during unoccupied periods.
 - 2.8.1.2 Adjustable temperature limits to restrict local wall mounted thermostat setpoint ranges.
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- 2.8.1.3 Visible and audible alarm indication of any system malfunctions with error code.
 - 2.8.1.4 Tiered hierarchy allowing for control of fan coil units independently or as a group.
 - 2.8.1.5 Remotely disable individual functions of the wall mounted zone controllers.
 - 2.8.1.6 Web enabled for remote access from PC, tablet or portable device and automatic alert and error emails.
 - 2.8.2 The following two automatic changeover methods shall be available. One shall be selected upon commissioning.
 - 2.8.2.1 Averaging Method – the central controller shall sum up the difference between room temperatures and set points for all indoor units in the system. Once this delta reaches the primary changeover dead band of $\pm 2^{\circ}\text{F}$ (adjustable), the central controller shall change over the system automatically.
 - 2.8.2.2 Voting Method – The central controller shall evaluate the difference between individual room temperatures and set points, and only include a fan coil in the algorithm if the difference has passed the primary dead band for more than the guard timer, or past the secondary dead band. Heating priority option shall be available.
 - 2.8.3 For both automatic changeover options, a weight (0-3) can be added to each indoor unit. The automatic changeover algorithm shall use this weighting to prioritize changeover for the more heavily weighted fan coils.
 - 2.8.4 Upon any changeover, a guard timer shall prevent another changeover for a period of 15, 30, or 60 (default) minutes.
 - 2.8.5 The guard timer shall be ignored by a change of setpoint manually from either the central controller or the remote controller, by schedule, or if the secondary dead band is reached with either of the automatic changeover algorithms. The secondary changeover dead band shall be the sum of the primary changeover dead band (adjustable) $\pm 1^{\circ}\text{F}$ (adjustable)
 - 2.8.6 The central controller shall have the capability for site floor plans to be uploaded as a background to create a graphics interface. Background shall be project specific floor plans rendered in “2D” or “3D”.
 - 2.8.7 Floor plan layout shall be displayed both on the local central controller, as well as accessible from the web.
 - 2.8.8 Floor plan will include capability to control indoor unit, and auxiliary inputs / outputs, such as designated lighting control, as follows:
 - 2.8.9 Up to 4 status points to be assigned to the control point icon (room name, room temperature, set point, and mode).
 - 2.8.10 Status and control points to display on corresponding location of zone served on floor plan.
 - 2.8.11 Digital input and output icons will display On/Off status.
 - 2.8.12 Analog input icons will display analog value.
 - 2.8.13 Up to 60 floor layout sections shall be possible depending on project scope.
 - 2.8.14 The BACnet Server Gateway Option shall be capable of making the controller work as a BACnet gateway using the BACnet/IP protocol. The BACnet Server Gateway Option shall be capable of exposing indoor unit management points as BACnet objects to the BMS.
 - 2.8.15 The BACnet Server Gateway Option shall allow the following functions:
 - 2.8.15.1 Support Change of Value (COV) notifications.
 - 2.8.15.2 Provide unique virtual BACnet device identification number (ID) for every indoor unit group address.
 - 2.8.15.3 The BACnet Server Gateway Option shall be capable of being configured as a foreign device. It shall be capable of communicating across BACnet Broadcast Management Devices (BBMD) in different subnet networks.
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- 2.8.16 In addition to the standard BACnet VRF points, the Building Management System shall monitor and/or control the following BACnet objects for indoor units:
 - 2.8.16.1 Occupancy Mode: Unoccupied, Occupied, Standby
 - 2.8.16.2 Cooling and heating setpoints during occupied and unoccupied modes.
- 2.8.17 The Building Management System may choose to monitor and control the following BACnet objects linked to controller control logic:
 - 2.8.17.1 Enable/Disable Schedule operation.
 - 2.8.17.2 Enable/Disable Auto Changeover Operation.
 - 2.8.17.3 Set Timed Override Minutes - Monitor and configure timer extension for the indoor unit on controller (30, 60, 90, 120, 150, 180 minutes)
 - 2.8.17.4 System forced off - Enable/Disable all emergency stop programs that are registered on the controller.
- 2.8.18 The BMS shall have the ability to utilize scheduling functions on the controller.
- 2.8.19 The BMS shall have the ability to utilize automatic changeover function on the controller, removing the need to program automatic changeover sequences on the BMS.
- 2.8.20 VRF manufacturer shall commission the BACnet server. BMS contractor shall provide VRF manufacturer with static IP address and instance number for commissioning. IP connection shall be by BMS contractor.
- 2.8.21 All programming for monitoring and control of VRF system via the BACnet server shall be by BMS contractor, as per the Sequence of Operation.
- 2.8.22 Centralized controller shall be complete with power distribution software with the ability to generate .csv files with power consumption data for each fan coil in the system. The software shall have the ability to assess how the power consumption of the condensing units shall be distributed to each fan coil. The energy consumption files shall be accessible from the web via a restricted security access.

2.9 ELECTRICAL

- 2.9.1 Provide Independent electrical power for fan coils and branch selector boxes.
- 2.9.2 Provide individual disconnect switches for each fan coil.
- 2.9.3 Control wiring shall be installed in a daisy chain configuration between all VRF components as per Manufacturer.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Provide VRF equipment consisting of exterior condensing units and indoor evaporator units as scheduled and/or indicated on the drawings.
 - 3.1.2 Units shall be stored and handled according to the manufacturer's recommendations. Units shall be kept clean and isolated from dust and debris.
 - 3.1.3 Contractor shall inspect all equipment upon delivery and notify shipping company and manufacturer immediately of any damage.
 - 3.1.4 Install condensing units on a flat surface level within 1/8 inch and elevate a minimum of 18" from ground or roof surface, on vibration isolation pads. Provide intermediate supports as recommended by the equipment manufacturer.
 - 3.1.5 Indoor evaporator units to be installed as located on the drawings. Confirm exact location prior to roughing-in.
 - 3.1.6 Install loose control components and perform required control wiring (except building automation system connections) between condensing unit and evaporator in conduit in accordance with manufacturer's control wiring schematic and wiring standards of electrical work.
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- 3.1.7 Connect condensing unit and indoor evaporator units with refrigerant piping in accordance with piping shop drawing schematic. Refer to Section 23 23 00. Provide any required additional refrigerant.
- 3.1.8 High/low pressure gas line, liquid, and suction lines must be individually insulated between the outdoor and indoor units.
- 3.1.9 Use refrigeration best practice to allow pipes to expand and contract freely. Review manufacturer installation instructions to ensure expansion joints are properly designed.
- 3.1.10 Connect water cooled condensing unit with hydronic piping in accordance with piping specification section.

3.2 *STARTUP AND ADJUSTING*

- 3.2.1 Pressure test all systems to 550 PSI after system has been vacuumed and held to below 500 microns for at least one hour. Review manufacturer installation instructions for proper pressure test procedures.
- 3.2.2 Design and install all piping as per TSSA and CSA B52 regulations and apply and obtain TSSA certification for all systems.
- 3.2.3 Contractor to carry the cost of a minimum of two (2) manufacturer field inspection to review installation and startup. Notify consultant minimum of five days prior to inspection.
- 3.2.4 Refer to Section 20 05 00 – Common Work Results for Mechanical; for equipment/system manufacturer certification and start-up requirements.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for electric heaters, including accessories.
- 1.1.2 Submit manufacturer's standard colour chart.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit a site start-up report from manufacturer's representative as specified in Part 3 of this Section.
- 1.2.2 Training attendance records.

2 PRODUCTS

2.1 GENERAL RE: ELECTRIC HEATERS

- 2.1.1 Electric heaters are to be certified and labelled in accordance with CSA C22.2 No. 46, Electric Air-Heaters, and are to be complete with automatic reset high limit temperature control, baked epoxy/polyester powder coat white or almond finish as selected, and in accordance with drawing schedule.
- 2.1.2 Manufacturers:
 - 2.1.2.1 Ouellet Canada Inc.;
 - 2.1.2.2 Chromalox Inc.;
 - 2.1.2.3 Stelpro Inc.

2.2 SLOPED TOP CONVECTOR HEATERS

- 2.2.1 Wall mounted sloped top electric convector heaters, each complete with:
 - 2.2.1.1 18 gauge steel cabinet, approximately 75 mm (3") wide, 250 mm (10") high, with 16 gauge steel removable front panel with pencil-proof louver grilles;
 - 2.2.1.2 standard watt density (900 W/m), noise free, steel tubular element with aluminium fins, floating on high-temperature nylon bushings;
 - 2.2.1.3 tamperproof, single pole, integral, factory installed thermostat, screwdriver adjustable and complete with "off" position;
 - 2.2.1.4 factory supplied enclosure accessories as indicated on drawings and/or heater schedule;
 - 2.2.1.5 factory installed relay section with 24 volt relay and transformer for site connection to a remote thermostat.

2.3 BASEBOARD HEATERS

- 2.3.1 Low profile wall mount baseboard heaters, each approximately 150 mm (6") high, 65 mm (2-½") deep, complete with:
 - 2.3.1.1 22 gauge steel body with 20 gauge steel connection box at both ends of heater, 2 rows of mounting holes, single screw built-in wire holder, and 20 gauge steel removable front panel with rounded upper corners;
 - 2.3.1.2 standard watt density (900 W/m) tubular steel heating element with aluminium fins, noise free and floating on high temperature nylon bushings;
 - 2.3.1.3 factory installed, tamperproof, adjustable bi-metal thermostat;
 - 2.3.1.4 factory supplied enclosure accessories as indicated on drawings and/or heater schedule;
 - 2.3.1.5 factory supplied control components in accordance with drawing schedule, with low voltage/line voltage barrier as required.

2.4 *MOTORIZED CABINET HEATERS*

- 2.4.1 Surface mounted or recessed cabinet heaters as shown, each complete with:
 - 2.4.1.1 18 gauge steel cabinet and removable front panel with integral louvers and grille with rounded corners;
 - 2.4.1.2 tubular steel heating element with aluminium fins;
 - 2.4.1.3 steel fan wheel, direct driven by means of a motor conforming to requirements of Section 20 05 00 – Common Work Results for Mechanical, and complete with a fan delay to purge heater of residual heat;
 - 2.4.1.4 remote, tamperproof, adjustable thermostat;
 - 2.4.1.5 factory installed, tamperproof, adjustable thermostat;
 - 2.4.1.6 factory supplied enclosure accessories as indicated on drawings and/or heater schedule;
 - 2.4.1.7 factory supplied control components in accordance with drawing schedule, with low voltage/line voltage barrier as required.

2.5 *MOTORIZED UNIT HEATERS*

- 2.5.1 Horizontal surface mounting unit heaters, each complete with:
 - 2.5.1.1 #20 gauge die-formed steel with individually adjustable discharge louvers, and mounting brackets for either ceiling or wall swivel mounting;
 - 2.5.1.2 tubular steel heating element with fins;
 - 2.5.1.3 resiliently mounted totally enclosed motor in accordance with requirements specified in Section 20 05 00 – Common Work Results for Mechanical, direct connected to a statically and dynamically balanced aluminium fan and complete with guard;
 - 2.5.1.4 factory installed, tamperproof, adjustable thermostat;
 - 2.5.1.5 factory supplied control components in accordance with drawing schedule, with low voltage/line voltage barrier as required;
 - 2.5.1.6 seismic restraint connection hardware factory secured to each unit.

3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Supply electric heaters, complete with all required accessories. Hand heaters, in original packaging, to electrical trade at site in room/area where they are to be installed.
- 3.1.2 Locate electric heaters for electrical trade so accurate electrical rough-in can be made. Confirm exact locations prior to electrical rough-in.
- 3.1.3 Ensure heaters are properly installed.
- 3.1.4 Brace and secure heaters in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.
- 3.1.5 Where remote thermostats are indicated, provide thermostats and required control wiring and accessories. Unless otherwise indicated, locate thermostats 1200 mm (48") above floor, and confirm exact thermostat locations prior to roughing-in.

3.2 *SYSTEM STARTUP*

- 3.2.1 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
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3.3 CLOSEOUT ACTIVITIES

- 3.3.1 Include for a 4 hour on-site heater operation demonstration and training session. Training is to be a full review of all components including but not limited to construction details, operation, and maintenance.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Description: Furnish and install a Klimatrol Environmental System's Radiant Floor Heating (RFH) system as manufactured by REHAU. System shall be complete with RaupeX piping and Everloc cold-expansion fittings. Tel: 905-454-1742.
- 1.1.2 The Cross-linked polyethylene (PEXa) pipe shall be high-pressure peroxide method with a minimum 80-85% cross-linking conforming to ASTM F876, ASTM F877, and CSA B137.5. and DIN 4726 oxygen diffusion. Fittings shall conform to ASTM F877, ASTM F2080, and CSA B137.5.
- 1.1.3 Additional components shall consist of 'ANURAV Pre-Assembled' c/w 5/8" RaupeX, Heat Exchanger, actuator, mixing valves, pumps, BACnet controllers, manifolds, R-20's, sensors, and manifolds. Installation accessories of Non-metallic pipe fasteners, tube protection sleeving, special tools, and pressure test kits.

1.2 REFERENCES

- 1.2.1 CSA B214-21, Standard for Installation of Radiant Floor Heating and Snow ice Melting systems.
- 1.2.2 ASTM F876, Standard Specification for Cross-linked Polyethylene (PEX) Pipe.
- 1.2.3 ASTM F877, Cross-linked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems.
- 1.2.4 ASTM F2080 and ASTM F1965, Standard Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for use with Cross-linked Polyethylene (PEX) Pipe.
- 1.2.5 CSA B137.5, Cross-linked Polyethylene (PEX) Tubing Systems for Pressure Application.
- 1.2.6 CAN/ULC-S102.2: accordance of Flame Spread Index less than 25 and Smoke Spread Index of less than 50.
- 1.2.7 DIN 4726, German Oxygen Diffusion Standard for Plastic Piping Used in Warm Water Floor Heating Systems.

1.3 SUBMITTALS

- 1.3.1 Provide submittals and shop drawings in accordance with the General Requirements and as specified herein. Shop drawings shall indicate schematic layout of system, including equipment, critical dimensions, and piping/slab penetration.
 - 1.3.2 Submit manufacturer's technical installation instructions.
 - 1.3.3 Submit independent certification results for the piping systems from a recognized testing laboratory.
 - 1.3.4 Submit system design indicating pipe sizing, floor construction, floor covering, tubing layout and output capacity at pipe spacing and water temperatures selected. Design calculations to be performed on pipe manufacturer's software using ASHRAE heat loss data on the basis of continuous 24 h/day, 7 day per week heating cooling operation.
 - 1.3.5 Submit catalog data on all equipment, fittings, fasteners, and associated items necessary for the installation of the piping and manifolds.
 - 1.3.6 Submit installer's certification and project installation resume of experience. System shall be installed by a contractor experienced in radiant floor cooling / heating system installation.
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1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Request services of the manufacturer to witness installation and pressure test prior to emplacement of thermal mass and to provide Letters of Inspection.
- 1.4.2 Training records and attendance list.
- 1.4.3 "As-Built" shop drawings, manuals, and warranty document.

1.5 DELIVERY, STORAGE, AND HANDLING

- 1.5.1 Deliver and store piping and equipment in shipping containers with labeling in place. Pipe to be kept in original shipping boxes until required for installation. Do not expose pipe to ultraviolet (sunlight) light for more than 30 days.
- 1.5.2 Protect piping and manifolds from entry of contaminating materials by installing suitable plugs on all open pipe ends until installation. Where possible, connect pipes to assembled manifolds to eliminate possibility of contaminants.
- 1.5.3 Piping shall be stored on a flat surface with no sharp edges.
- 1.5.4 Pipe shall be protected from oil, grease, paint, direct sunlight, and other elements as recommended by manufacturer.

1.6 WARRANTY

- 1.6.1 The radiant floor heating pipe manufacturer shall warrant the cross-linked polyethylene piping and any "Everloc" fittings, to be free from defects in material and workmanship for a period of twenty-five (25) years. The design shall be approved either by submittal or stamped by a registered engineer as being complete and accurate.
- 1.6.2 All manifolds and controls shall be warranted for 18 months and/or two heating seasons.
- 1.6.3 Coordinate services of Klimatrol Environmental Systems Ltd to provide Letters of Inspection of installation and witnessing pressure test prior to the thermal mass emplacement. Klimatrol shall provide Owner Training on proper operation and maintenance of the system and provide owner with "As-built" shop drawings, manuals, and certified Installation Warranty.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Klimatrol Environmental Systems Ltd (905) 454-1742) / Rehau including installation supervision and Letters of Inspection and commissioning.
- 2.1.2 Alternates may only be considered with product application request submitted two weeks prior to tender, in writing, outlining all system components, proposed layout, site supervision service, warranty compliance and list of 10 projects of similar scope completed in the last 5 years. Any alternate manufacturer shall bear the cost of engineering review and revisions.

2.2 PIPING

- 2.2.1 Material: All radiant floor heating piping shall be nominal high density cross-linked polyethylene as manufactured by REHAU using the peroxide method of cross-linking (PEXa) and with an approved cell classification in accordance with ASTM D3350. Pipe shall conform with ASTM F876, and CSA B137.5, and be certified by CSA.
 - 2.2.2 Temperature and Pressure Ratings: Piping shall be rated for 100 psig gauge pressure at 180°F temperature (690 kPa @ 82°C) continuous, and 80 psig gauge pressure at 200°F temperature (550 kPa @ 93°C) continuous.
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- 2.2.3 Oxygen Diffusion Barrier: Piping shall have a co-extruded oxygen diffusion barrier capable of limiting oxygen diffusion through the pipe to less than 0.10 mg/L/day at 104°F (40°C) water temperature, in accordance with DIN 4726.
- 2.2.4 Bend Radius: The minimum bend radius for cold bending of the pipe shall be not less than five (5) times the outside diameter. Bends with a radius less than this shall require the use of a bending template as supplied by the pipe manufacturer, and/or hot air.
- 2.2.5 Install Radiant heating cooling piping in pattern as shown on Klimatrol shop drawings. Counter flow spiral layout shall be required on slab cooling applications and spiral pattern for general heating applications.

2.3 FITTINGS

- 2.3.1 Fittings shall be manufactured of dezincification-resistant brass and shall be supplied by the piping manufacturer as a proven part of cataloged system. Manifold fittings shall be compression nut style with split compression ring.
- 2.3.2 Fittings shall be certified to ASTM F877, ASTM F2080, and CSA B137.5 as part of the manufacturer's PEX piping system. Pipe couplings embedded within the thermal mass or behind drywall shall be EVERLOC cold-expansion compression-sleeve fittings.

2.4 MANIFOLDS

- 2.4.1 Material: Distribution manifolds shall be manufactured of dezincified brass or stainless steel and be a proven cataloged part of the manufacturer's system.
- 2.4.2 Rehau Pro-Balancing Manifolds shall be equipped with visual circuit flow gauges, balancing valves, and isolation valves for each circuit. Manifold isolation valves, air vent, and drain service ports shall be pre-assembled and mounted on metal brackets ready to install.
- 2.4.3 Each manifold shall be provided with automatic air vent.
- 2.4.4 Manifolds shall be incorporated into Pre-Build KLIMAPANEL

2.5 KLIMAPANEL AND CONTROLS

- 2.5.1 KLIMAPANEL pre-built pump / mixing panel shall maintain space and floor temperature setpoints. The panels shall consist of 0-10 Vdc mixing valve and slow opening 24 V zone control valves, space for BAS controller including temperature mixing and slab safety features.
 - 2.5.2 Supply, Return and Floor Slab sensors shall be a 10 kΩ NTC Type II thermistor (supplied by Klimatrol.) BAS shall sense space temperature and floor slab temperature with target air temperature of (72°F), floor slab not to exceed 91°F (33°C) at design heating output and (95°F) maximum slab temperatures. Maximum supply water temperature limit of 140°F and shall not be exceeded. System shall de-energize if maximum temp is exceeded by 2°F or more for a period greater than 10 minutes. If no call for heat is received Manifold zone valves and circulators shall operate for a minimum of 10 minutes then shutdown. Radiant floor heating system shall be enabled on outdoor temperature below 68 F. if registered for a period greater than one hour. Provide and install spare slab sensors.
 - 2.5.3 KLIMAPANEL BACnet Controller shall track the long-term "trailing average daily outdoor air (dry-bulb) temperature (OAT). Outdoor Air temperature readings are recorded hourly. Number of days determining the averaging time period is two days (adjustable). Slab target temperature is calculated daily from the linear function derived from the setpoints defined for peak heating and cooling conditions and the current "trailing average daily outdoor dry bulb temperature" (OAT adj). Default settings for each zone (adjustable through BAS).
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- 2.5.4 Supply sensors shall be mounted on manifolds and KLIMAPANEL controller shall prioritize modulating supply fluid temperature to maintain target supply temperature.
- 2.5.5 Space temperatures in individual zones shall be provided indirectly back to KLIMAPANEL via BAS. BAS Shall provide space sensors.
- 2.5.6 Water cooled fractional horsepower 120 V/1 Ph, FLA: 3 amp pumps shall be silent and energy efficient as manufactured by Grundfos and sized specifically for area being heated.
- 2.5.7 Heat exchanger shall be pre-built into KLIMAPANEL as required for glycol anti-freeze applications or separation from building hydraulic pressures in excess of 100 psig. Heat exchanger shall be rated and warranted for 450 psi. Panels with heat exchanger shall include expansion tank and glycol auto fill system.
- 2.5.8 KLIMAPANEL Shall be complete with BACnet ready controls.

2.6 ACCESSORIES

- 2.6.1 Required installation accessories shall include nylon cable binders or Railfix tube track, pipe conduit bend guides, protective sleeving, pressure test kit, pipe cutter, pipe uncoiler, Everloc tool kit and other installation tools and aids required for complete installed and approved system.

3 EXECUTION

3.1 PREPARATION

- 3.1.1 Concrete Slab on Grade: Subgrade should be compacted, flat and smooth to prevent damage to pipe or insulation. Approved vapor barrier material should be installed. Insulation shall be installed vertically along all exterior walls or footings to which the edge of the slab will meet against. Horizontal insulation shall be installed flat against the vapor barrier under which the slab will be poured. Reinforcing wire mesh or rebar, if required by structural design, must be flat and level, with all sharp ends pointing down. Finished grade of the thermal mass shall be minimum of 3/4" (19 mm) above the top of PEX heating pipes.
 - 3.1.2 Install floor heating piping in a combination spiral / counter flow spiral design pattern as shown on the Klimatrol piping design shop drawings.
 - 3.1.3 All floor heating piping shall be fastened using nylon cable binders to a middle rebar mesh (provided by general contractor) maintaining a consistent level and minimum 50 mm pipe clearance from top or bottom of the concrete slab. Preferred level is just above midpoint of the concrete slab. Coordinate mesh elevation in slab for low level in radiant ceilings or high level in radiant floors.
 - 3.1.4 Pre-cast Concrete Subfloor: Subfloor must be clean and free from all construction debris and sharp edges. Replace any areas that appear weak. If called for by design, approved vapor barrier and insulation shall be installed vertically along all exterior walls slab edges as well as flat under where the slab will be poured. Finished grade of the thermal mass overpour must be a minimum of 3/4" (19 mm) above the top of PEX heating pipes.
 - 3.1.5 Manifold Installation and Preparation of Wall Cavity: Review drawings and/or design to determine proper locations for manifolds. Check cabinet specifications to determine the size of the wall opening dimensions. Typical cabinets are 24" H x 30", 36" 42" or 48" Wide and 7" Deep. Mount the manifold cabinet minimum 100 mm (4") above finished surface. If a cabinet is not used, prepare a suitable cavity for the manifold providing a secure mounting plate that will place the manifold at least 720 mm (28 in) above floor level. If a manifold is to be installed on a wall that will not be constructed until after the heating pipe installation, then a temporary support must be built to secure the manifold in the location
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that it will stay in after the wall is constructed. Manifold must be installed in an area that will allow easy access for supply/return piping as well as future access for maintenance.

3.2 INSTALLATION

- 3.2.1 Install in accordance with manufacturer's published installation manual and/or published guidelines.
- 3.2.2 Mount manifolds in the locations previously prepared or in previously installed cabinets, if used. Manifolds should be mounted level and wrapped in plastic to be protected during construction from dirt, dust, or concrete during pour.
- 3.2.3 Route piping in neat and professional manner, according to layout and spacing shown in approved submittal drawings. All notes on drawings shall be followed.
- 3.2.4 Avoid installing tubing under built-ins or within 150 mm (6 in) of walls, floor plates or any floor penetrations. Mark locations of in-slab piping on concrete surfaces so other trades avoid slab drilling, coring, anchoring or penetrations.
- 3.2.5 For crack control ensure thermal slab is segmented into smaller sections by movement joints or saw cut, avoid crossing movement joints. Any Saw cuts shall not exceed $\frac{3}{4}$ " (19 mm) depth and not score installed pipe.
- 3.2.6 Provide Slab sensor conduit sleeve from manifold to zone locations. See shop drawing and mechanical drawings for thermal zoning layout. Use separate loops for different rooms allowing for better temperature control. Maximum under floor covering subsurface temperature shall not exceed 100°F (38°C). Thinner denser floor coverings preferred for better heat transfer, do not exceed Maximum Surface temperatures of 85°F in occupied areas, 90°F in high traffic and washroom areas and 95°F in perimeter areas.
- 3.2.7 At connections and fittings, use a Rehau plastic pipe cutter to ensure square and clean cuts, join pipes immediately or cap ends of pipe to seal from contaminants. Where fittings are installed within the thermal mass, they shall be wrapped in chloride-free tape or sealed within a heat-shrink material approved by the manufacturer.
- 3.2.8 Pipe should be dispensed using an uncoiling device. Remove all twists prior to securing pipe. Pipe must lie flat on an even plane. Install tubing at a consistent depth below surface. Finished grade of a thermal mass must be a minimum of $\frac{3}{4}$ " (19 mm) above the top of PEX heating pipes. Fasten piping at no more than 3 feet (900 mm) intervals, being careful not to twist the pipe. In thin concrete slabs, it may be necessary to secure piping every 2 feet (600 mm). Use only fasteners supplied or approved by the manufacturer of the PEX pipe.
- 3.2.9 Piping that must pass through expansion joints shall be covered in protective polyethylene convoluted sleeving (flexible conduit) extending 200 mm (8 in) on each side of the joint. Sleeving must be secured on pipe to prevent movement during installation of thermal mass.
- 3.2.10 Where piping exits the thermal mass, a protective conduit shall be placed around the pipe, with the conduit extending a minimum of 150 mm (6 in) into the floor and exiting by a minimum of 6 inches. For penetrations at manifolds, use rigid PVC bend guides secured in place to prevent movement.
- 3.2.11 At the time of installation of each circuit of pipe, connect the pipe to the correct manifold outlet and record pipe length for balancing. If manifold is not installed, cap the end of the pipe and label the pipe's circuit numbers along with S for supply and R for return. Connect pipes to manifold as soon as possible and record circuit lengths. Label all circuits to indicate circuit length and zone area.
- 3.2.12 The following precautions shall be taken in areas intended for carpet:
 - 3.2.12.1 Notify carpet installer that radiant heating pipes have been installed.
 - 3.2.12.2 Keep pipes 150 mm (6 in) from all wall baseplates.

- 3.2.12.3 Avoid or Install metal guards where pipe will pass through wall baseplates and where carpet tack strips will be installed.
- 3.2.13 The following precautions shall be taken in areas intended for hardwood flooring:
 - 3.2.13.1 Ensure that nailing areas for hardwood flooring (if nailing is required) are clearly marked and known to hardwood installers.
- 3.2.14 The heating system should not be put into operation until the poured concrete thermal mass has cured a minimum of 28 days, unless otherwise specified and approved by thermal mass supplier. If it is necessary to operate the heating system to prevent freezing, a maximum flow temperature of 72°F (22°C) must not be exceeded while the thermal mass is curing. After curing, gradually increase the flow temperature by no more than 10°F (6°C) each day until system reaches the required operating temperature.
- 3.2.15 General Contractor shall be responsible for provision of minimum 50 mm (2") thick 60 psig compressive strength rigid insulation. General Contractor shall also provide wire mesh or rebar to secure tubing. Coordinate with Architectural and Structural details and plans. Insulation thickness can decrease to ½" (R2.5) if system installed over a heated space.
- 3.2.16 Mechanical Contractor shall be responsible for provision of:
 - 3.2.16.1 Labour to install Radiant Floor Heating system.
 - 3.2.16.2 Water, glycol, and any chemical solutions.
 - 3.2.16.3 Field coordination of the pressure test equipment. (It is recommended to use the REHAU hydraulic pressure test unit available through Klimatrol to conduct pressure tests.)
 - 3.2.16.4 Supervision of concrete pours to instruct concrete installers on maintenance of pipe integrity and position of pipe in slab during concrete installation.
 - 3.2.16.5 Installation of control valves, pumps, supply and return piping, all valves, and fittings.
 - 3.2.16.6 Electrical control interconnection and commissioning

3.3 FIELD QUALITY CONTROL

- 3.3.1 Request services of Klimatrol Environmental Systems to inspect and witness installation prior to emplacement of thermal mass.
- 3.3.2 Manifold Filling, Testing, and Balancing: Test the hydronic heating system in compliance with local codes, and, where required, shall be witnessed by the building official as well as Klimatrol Environmental Systems Ltd. (Reference BOCA, ICBO, SBCCI or the acceptable code body for the jurisdiction).
 - 3.3.2.1 Pressure gauges used must show pressure increments of 1 psig and should be located at or near the lowest points in the distribution system.
- 3.3.3 Air Test: Charge the completed, yet unconcealed pipes with air. Do not exceed 120 psig. Use liquid gas detector or soap solution to check for leakage at manifold connections.
 - 3.3.3.1 Perform a preliminary pressure test pressurizing the system to the greater of 68 psi or 1.5 times the maximum operating pressure. As the piping expands, restore pressure, first at 10 minutes into the test and again at 20 minutes. At the end of the 30 minute preliminary test, pressure must not fall by more than 5 psig from the maximum, and there shall be no leakage.
 - 3.3.3.2 Perform the main pressure test immediately thereafter. The main pressure test shall not fall more than 3 psig after 2 hours and until system is placed into operation. No leakage should be detected.
 - 3.3.3.3 Pressure shall be maintained and monitored during installation of the thermal mass. If any leak is detected during installation of thermal mass, the leak must be found immediately, and the area cleared for repair using manufacturer approved repair coupling. Retest before covering repair.

- 3.3.4 Water Test: Purge all air from pipes. Charge the completed, yet unconcealed pipes with water. Take necessary precautions to prevent water from freezing. Check the system for leaks, especially at all pipe joints.
 - 3.3.4.1 Perform the same procedures as used in the Air Test.

3.4 CLOSEOUT ACTIVITIES

- 3.4.1 Request services of Klimatrol Environmental Systems to witness installation and pressure test prior to emplacement of thermal mass and to provide Letters of Inspection. Coordinate with Klimatrol for Owner or Owner's Representative's training on correct operation and maintenance of the system. Provide Owner with "As-Built" shop drawings, manuals, and warranty document.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

- 1.1.1 Submit shop drawings/product data sheets for following:
 - 1.1.1.1 all control system components;
 - 1.1.1.2 identified schematic control diagrams with component identification, catalogue numbers, and sequence of operation for all systems;
 - 1.1.1.3 certified wiring diagrams for all systems.
- 1.1.2 Submit following samples for review:
 - 1.1.2.1 control damper section with linkage, operator, and certified flow and leakage data;
 - 1.1.2.2 wall mounting control system flow diagram as specified in Part 2 of this Section;
 - 1.1.2.3 each type of thermostat to be used, each identified as to intended use.

1.2 CLOSEOUT SUBMITTALS

- 1.2.1 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.
- 1.2.2 Submit written confirmation from control component manufacturer that site installation personnel are qualified and experienced in installation of components, and have parts and service availability on a 24/7 basis.

1.3 QUALITY ASSURANCE

- 1.3.1 Control systems are to be installed by control component manufacturer or by licensed personnel authorized by control component manufacturer. Submit written confirmation from control component manufacturer.
- 1.3.2 Control wiring work is to be performed by licensed journeyman electricians, or under direct daily supervision of journeyman electricians.

2 PRODUCTS

2.1 CONTROL DAMPERS AND OPERATORS

- 2.1.1 T. A. Morrison & Co. Inc. "TAMCO" 100 mm (4") deep, flanged, AMCA low leakage certified aluminium dampers. Dampers for modulating and mixing applications are to be parallel blade type. Dampers for open-shut service are to be opposed blade type. Maximum blade length is to be 1 m (4'). Dampers greater than 2 sections wide are to be complete with a jackshaft. Each damper is to be complete with:
 - 2.1.1.1 extruded 6063T5 aluminum frame and airfoil blades, each with an integral slot to receive a gasket;
 - 2.1.1.2 extruded TPE frame gaskets and extruded EPDM blade gaskets;
 - 2.1.1.3 slip-proof aluminium and corrosion resistant plated steel linkage of a metal thickness to prevent warping or bending during damper operation, concealed in frame, equipped with seal-sealing and self-lubricating bearings consisting of a Celcon inner bearing fixed on hexagonal blade pin and rotating in a polycarbonate outer bearing inserted in frame.
 - 2.1.2 For standard damper(s), Series 1000 as above.
 - 2.1.3 For insulated damper(s), Series 9000 as above but with all 4 sides of frame insulated with polystyrene, and blades thermally broken and insulated with expanded polyurethane foam.
 - 2.1.4 For stainless steel dampers, as above but constructed of type 316 stainless steel and equipped with Teflon blade bearings.
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- 2.1.5 Each damper motor is to be shaft mounted, spring return, fail safe in the normally open or normally closed position, sized to control damper against maximum pressure or dynamic closing pressure, whichever is greater, to suit sizes of dampers involved, and to provide sufficient force to maintain damper rated leakage characteristics. Each operator is to be complete with a damper position indicator, and external adjustable stops to limit length of stroke in either direction, and is to be mounted on a corrosion resistant adjustable bracket. Operating arms are to have double yoke linkages and double set screws for fastening to damper shaft. Operators for dampers to be connected to building fire alarm system or to freeze protection devices are to be equipped with additional relays to permit dampers to respond and go to required position in less than 15 seconds upon receipt of a signal. Operator enclosures are to be suitable in all respects for environment in which they are located.
- 2.1.6 Electric damper operators are to be equal to Belimo EF Series 24 volt or 120 volt AC spring return, direct coupled electric motor operators for either modulating or 2-position control as required. Each operator is to be overload protected and complete with an enclosure to suit the mounting location.
- 2.1.7 Pneumatic damper operators are to be replaceable elastomer diaphragm piston type, suitable in all respects for damper sequence.

2.2 LOCAL CONTROL PANELS

- 2.2.1 NEMA 1 (NEMA 2 in sprinklered areas) wall mounting, enamelled steel barriered enclosures sized to suit the application with 20% spare capacity, a perforated sub-panel, numbered terminal strips for all low and line voltage wiring, hinged door, and slotted flush latch.

2.3 CONTROL SYSTEM COMPONENTS

- 2.3.1 Components specified below are required for control of equipment and systems in accordance with drawing control diagrams and sequences of operation. Not all required components may be specified.
- 2.3.2 Sensor/transmitter input devices must be suitable in all respects for the application and mounting location. Devices are as follows:
 - 2.3.2.1 unless otherwise specified, temperature sensors are to be resistance type, either 2-wire 1000 Ω nickel RTD or 2-wire 1000 Ω platinum RTD with accuracy (includes errors associated with sensor, lead wire, and A to D conversion), equipped with type 316 stainless steel thermowells for pipe mounting applications, as follows:
 - (1) chilled water, room temperature, and duct temperature points, $\pm 1^{\circ}\text{C}$ ($\pm 0.5^{\circ}\text{F}$);
 - (2) all other points, $\pm 0.75^{\circ}\text{C}$ ($\pm 1.3^{\circ}\text{F}$).
 - 2.3.2.2 room temperature sensors constructed to be selected in accordance with the following classifications:
 - (1) Type 1: Space temperature sensor (private/non-public areas);
 - (A) for measurement of space temperature only as shown on the floor plans and/or as described in the Sequence of Operation;
 - (B) set-point adjustment shall be accessible through the cover;
 - (C) sensor operating temperature range from 4°C to 60°C (40°F to 140°F);
 - (D) surface mounted plastic mono-chromatic guard with surface mounting plate and wall anchors;

- (E) mono-chromatic guard secured to mounting plate by screws;
 - (2) Type 2: Space temperature sensor (public areas or secure areas);
 - (A) for measurement of space temperature of space temperature only in areas subject to vandalism as shown on the floor plans and/or as described in the Sequence of Operation;
 - (B) sensor operating temperature range from 4°C to 60°C (40°F to 140°F);
 - (C) stainless steel flat plate surface type with sensor epoxy-bonded to back of cover plate;
 - (D) tamperproof/secure concealed fasteners;
 - (E) set-point adjustment is to be concealed behind the cover.
 - (3) Type 3: Adjustable space temperature sensor with display (Private Areas, Office areas);
 - (A) for measurement and adjustment of space temperature as shown on the floor plans and/or as described in the Sequence of Operation;
 - (B) digital set point operating temperature adjustment range from 4°C to 60°C (40°F to 140°F);
 - (C) surface mounted plastic mono-chromatic guard with surface mounting plate and wall anchors;
 - (D) mono-chromatic guard secured to mounting plate by screws;
 - (E) on/off button to allow occupant override feature;
 - (F) three-digit LED digital temperature display with 0.2° display resolution;
 - (G) 5% to 95% relative humidity, non-condensing;
 - (H) minimum/maximum limit set point values adjustable from the BAS operator interface and controller.
 - (I) set-point adjustment is to be accessible through the cover.
 - 2.3.2.3 outside air sensors designed and constructed for an ambient temperature of -25°C to 60°C (-13°F to 140°F) and 5% to 95% relative humidity, non-condensing, complete with a NEMA 3R enclosure, solar shield, a weatherproof seal at all wall penetrations, and a perforated plate surrounding sensor element where exposed to wind velocity pressure;
 - 2.3.2.4 insertion duct mounting sensors type with lock nut and mounting plate, designed to mount in an electrical box (weather-proof with gasket and cover where outside) through a hole in duct;
 - 2.3.2.5 for ducts greater than 1.2 m (4') or for ducts where air temperature stratification occurs, averaging type sensors with multiple sensing points, and for plenums for applications such as mixed air temperature measurement to account for air turbulence and/or stratification, an averaging string of sensors with capillary supports on the sides of duct/plenum;
 - 2.3.2.6 Where both temperature and humidity are shown to be measured at same location or in same airstream, use of single measuring unit is permitted provided that features and performance of both temperature sensor and humidity sensor are in accordance with requirements of this specification.
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- 2.3.3 factory solid-state relative humidity sensors with an element that resists contamination, weather-proof with a NEMA 3R enclosure for outside air applications, supplied with a type 304 stainless steel probe with mounting bracket and hardware for duct mounting, each complete with a factory calibrated humidity transmitter which is accurate (including lead loss and analog to digital conversion) to 3% between 25°C to 60°C (-13°F to 140°F) and 5% to 95% relative humidity, non-condensing and complete with non-interactive span and zero adjustments, and a 2-wire isolated loop powered, 4-20 mA, 0 to 100% linear proportional output;
 - 2.3.4 carbon dioxide sensors for air quality control purposes having a maximum 20 second response time, suitable for operating conditions from 0°C to 50°C (32°F to 122°F) and 0 to 100% RH non-condensing, complete with a calibration kit (to be handed to Owner) and characteristics as follows:
 - 2.3.4.1 measurement range: 0 to 2000 ppm;
 - 2.3.4.2 accuracy: ± 100 ppm;
 - 2.3.4.3 repeatability: ± 20 ppm;
 - 2.3.4.4 drift: ± 100 ppm per year;
 - 2.3.4.5 output signal: 0 to 10 VDC proportional over the 0 to 2000 ppm range.
 - 2.3.5 Pressure transmitters are to be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input. Pressure transmitters are to transmit a 0 to 5 VDC, 0 to 10 VDC, or 4-20 mA output signal. Differential pressure transmitters used for flow measurement are to be sized to the flow sensing device and supplied with a tee fitting and shut-off valves in the high and low sensing pick-up lines to allow permanent ease of use connection for balancing, etc. Transmitter housing is to suit mounting location. Standalone pressure transmitters are to be mounted in a minimum NEMA 1 (NEMA 2 in sprinklered area) by-pass valve assembly panel with high and low connections piped and valved, air bleed units, by-pass valves, and compression fittings. Transmitters are to be as follows:
 - 2.3.5.1 low differential water pressure, 0 kPa to 5 kPa (0 to 20" wc): equal to Setra or Mamac industrial quality transmitter capable of transmitting a linear 4-20 mA output signal in response to variation of flow meter differential pressure or water pressure sensing points, each complete with non-interactive zero and span adjustments adjustable from outside the cover, and performance as follows:
 - (1) maintain accuracy up to 20 to 1 ratio turndown;
 - (2) reference accuracy: +0.2% of full scale.
 - 2.3.5.2 medium to high differential water pressure, over 5 kPa (20" wc): equal to Setra or Mamac transmitters as specified above for low pressure transmitters but with a pressure range of from 2.5 kPa (10" wc) to 2070 kPa (300 psi), a reference accuracy of $\pm 1\%$ of full span (includes non-linearity, hysteresis, and repeatability);
 - 2.3.5.3 building differential air pressure: equal to Setra or Johnson Controls Inc. industrial quality transmitter with a range suitable for the application, capable of transmitting a linear 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points, each complete with non-interactive zero and span adjustments adjustable from outside the cover, and performance as follows:
 - (1) maintain accuracy up to 20 to 1 ratio turndown;
 - (2) reference accuracy: +0.2% of full span.
 - 2.3.5.4 low differential air pressure, 0 kPa to 1.25 kPa (0" to 5" wc): equal to Setra or Johnson Controls Inc. industrial quality transmitter with a range suitable for the application, capable of transmitting a linear 4-20 mA output signal in response to variation of differential pressure or air pressure sensing points, each
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- complete with non-interactive zero and span adjustments adjustable from outside the cover, and performance as follows:
- (1) maintain accuracy up to 20 to 1 ratio turndown;
 - (2) reference accuracy: +0.2% of full span.
- 2.3.5.5 medium differential air pressure, over 1.5 kPa (5" wc): equal to Setra or Johnson Controls Inc. transmitters as specified above for low pressure air transmitters but performance requirements as follows:
- (1) zero and span: (c/o F.S./Deg. F); 0.04% including linearity, hysteresis, and repeatability;
 - (2) accuracy: 1% F.S. (best straight line); static pressure effect: 0.5% F.S.;
 - (3) thermal effects: less than +0.33 F.S./°F over 40°F to 100°F (calibrated at 70°F).
- 2.3.6 Air and water flow monitoring stations and probes are to be Air Monitor Corp., Tek-Air Systems Inc., Ebtron, or Dietrich Standard products as follows:
- 2.3.6.1 Fan Inlet Air Flow Measuring Station: At fan inlet and near exit of inlet sound trap, air flow traverse probes are to continuously monitor fan air volume and system velocity pressure, and traverse probes are to be as follows:
- (1) each probe is to be of a dual manifold, cylindrical, anodized type 3003 extruded aluminium construction probe with sensors located along the stagnation plane of approaching air flow, and the static pressure manifold is to incorporate dual offset static tops on opposing sides of averaging manifold so as to be insensitive to flow angle variations for as much as $\pm 20^\circ$ in approaching air stream;
 - (2) each probe is not to introduce a measurable pressure drop, nor is sound level within duct to be amplified by its singular or multiple presence in air stream, and each probe is to contain multiple static and total pressure sensors placed at equal distances along its length in accordance with ASHRAE Standards for duct traversing.
- 2.3.6.2 Single Probe Air Flow Measuring Sensor: Duct mounting hot wire anemometer type which utilizes 2 temperature sensors, one is a heater element temperature sensor and the other is to measure downstream temperature, with temperature differential related directly to air flow velocity. Sensor insertion length is to be adjustable up to 200 mm (8"), and transmitter is to produce a 4-20 mA or 0-10 VDC signal linear to air velocity.
- 2.3.6.3 Duct Flow Measuring Stations: #14 gauge galvanized steel casing with duct connection flanges of a size to mate with connecting ductwork, and complete with an air directionalizer and a 98% free area parallel cell 20 mm ($\frac{3}{4}$ ") honeycomb profile suppressor across entering air stream to equalize velocity profile and eliminate turbulent and rotational flow from the air stream prior to measuring point, mechanically fastened to casing so as to withstand velocities of up to 1828 m (6000') per minute. Additional requirements as follows:
- (1) total pressure measurement side (high side) is to be designed and spaced to requirements of Industrial Ventilation Manual, 16th Edition, page 9-5, and self-averaging manifolding is to be constructed of brass and copper components;
 - (2) static pressure sensing probes (low side) is to be bullet-nose shaped, per detailed radius, as illustrated in Industrial Ventilation Manual referred to above, page 9-5;
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- (3) main take-off point from both total pressure and static pressure manifolds is to be symmetrical, and manifolds are to terminate with external ports for connection to control tubing;
 - (4) each station is to be equipped with a label on casing indicating unit model number, size, area, and specified air flow capacity;
 - (5) each station is to have a self-generated sound rating of less than NC 40, and sound level within duct is not to be amplified nor is additional sound to be generated.
 - 2.3.6.4 Static Pressure Traverse Probe: Duct mounting, complete with multiple static pressure sensors located along exterior surface of cylindrical probe.
 - 2.3.6.5 Shielded Static Air Probe: Indoor type or outdoor type as required, each with multiple sensing ports, an impulse suppression chamber, and air flow shielding.
 - 2.3.6.6 Water Flow Monitoring: Equal to Onicon microprocessor-based electromagnetic water flow meters with an accuracy of 0.25%.
 - 2.3.7 Power (amps) monitoring is to be performed by a combination of a current transformer and a current transducer with transformer sized to reduce full amperage of monitored circuit to a maximum 5 ampere signal which will be converted to a 4-20 mA DDC compatible circuit for use by building automation system. Current transformer and current transducer are as follows:
 - 2.3.7.1 equal to Veris Industries split core current transformer with an operating frequency of from 50 Hz to 400 Hz, 0.6 kV class, 10 kV BIL insulation, and 5 ampere secondary;
 - 2.3.7.2 equal to Veris Industries current to voltage or current to mA transducer with an accuracy of $\pm 5\%$, a minimum load resistance of 30k Ω , an input of 0 A to 20 amperes and an output of 4-20 mA, and a 24 VDC regulated power supply.
 - 2.3.8 Duct mounting smoke detectors supplied as part of electrical work for mounting as part of control system work.
 - 2.3.9 Double contact switches to monitor equipment status and safety conditions, and generate alarms when a failure or abnormal condition occurs. Status and safety switches are to be as follows:
 - 2.3.9.1 current sensing switches: equal to Veris Industries self-powered dry contact output switches for sensing run status of motor loads, each calibrated to indicate a positive run status only when motor is operating under load, and each consisting of a current transformer, a solid-state current sensing circuit, adjustable trip point, solid-state switch, SPDT relay, and a LED to indicate on or off status;
 - 2.3.9.2 air filter status switches: equal to Johnson Controls Inc. or Cleveland Controls automatic reset type differential pressure switches, each complete with SPDT contacts rated for 2 A at 120 VAC, a scale range and differential pressure adjustment appropriate for the service, and an installation kit which includes static pressure taps, tubing, fittings, and air filters;
 - 2.3.9.3 air flow switches: equal to Johnson Controls Inc. or Cleveland Controls pressure flow switches, bellows actuated mercury switch or snap-acting micro-switch type with an appropriate scale range and pressure adjustment;
 - 2.3.9.4 air pressure safety switches: equal to Johnson Controls Inc. or Cleveland Controls manual reset switches, each complete with SPDT contacts rated for 2 A at 120 VAC and an appropriate scale range and pressure adjustment;
 - 2.3.9.5 water flow switches: equal to Johnson Controls Inc. Model P74;
 - 2.3.9.6 low temperature limit switches: manual reset type equal to Johnson Controls Inc. Model A70, each complete with DPST snap acting contacts rated for 16 A at 120 VAC, a minimum 4.5 m (15') sensing element for mounting horizontally across duct/plenum with sensing reaction from coldest 450 mm (18") section of
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- element, and where sensing element does not provide full coverage of air stream, additional switches are to be supplied as required.
- 2.3.10 Control relays as follows:
- 2.3.10.1 control pilot relays: equal to Johnson Controls Inc. or Lectro modular plug-in design with snap-mount mounting bases, retaining springs or clips, DPDT, 3 PDT or 4 PDT as required for the application, with contacts rated for 10 A at 120 VAC;
 - 2.3.10.2 lighting control relays: latching type with integral status contacts rated for 20 amperes at 120 VAC, each complete with a split low voltage coil that moves the voltage contact armature to On or Off latched position, each controlled by a pulsed tri-state output (preferred) or pulsed paired binary outputs, and each designed so power outages will not result in a change-of-state and so multiple same state commands will simply maintain commanded state.
- 2.3.11 Electronic signal isolation transducers equal to Advanced Control Technologies for installation whenever an analog output signal from building automation system is to be connected to an external control system as an input (i.e. equipment control panel), or is to receive as an input signal from a remote system, and to provide ground plane isolation between systems.
- 2.3.12 Each manual override station is to be complete with contacts rated minimum 1 ampere at 24 VAC and is to provide following:
- 2.3.12.1 integral H-O-A switch to override controlled device pilot relay;
 - 2.3.12.2 status input to building automation system to indicate whenever switch is not in the Auto position;
 - 2.3.12.3 status LED to illuminate whenever output is On;
 - 2.3.12.4 override LED to illuminate whenever H-O-A switch is in either the Hand or Off position.
- 2.3.13 Electronic/pneumatic transducers equal to Johnson Controls Inc. transducers with an output of from 3 psig to 15 psig, an input of from 4-20 mA or 0-10 VDC, manual output adjustment, a pressure gauge, and an external replaceable supply air filter.
- 2.3.14 Thermostats:
- 2.3.14.1 Wall mounting adjustable set-point thermostats, each suitable in all respects for equipment (and operating sequence) they are provided for, equipped with a thermometer, a cover and any required mounting and connection accessories.
 - 2.3.14.2 Pneumatic thermostats are to be of bimetal element construction, double valve type, operating without constant waste of air.
 - 2.3.14.3 Line voltage thermostats are to be 115 V.
 - 2.3.14.4 Low voltage thermostats are to be 24 volt electronic type.
 - 2.3.14.5 Set-point adjustment for thermostats in public spaces is to be concealed behind cover. Set-point adjustment for other thermostats is to be accessible through cover.
 - 2.3.14.6 Covers are to be removable, tamper-proof covers with temperature set-point and thermometer displays.
 - 2.3.14.7 Guards for thermostats are to be clear, ventilated acrylic covers with allen key locking hardware.
- 2.3.15 Humidistats:
- 2.3.15.1 Direct or reverse acting (to suit system), proportional type, adjustable humidity controllers, each corrosion resistant, suitable in all respects for the application and complete with a nylon element, replaceable cartridge type air filter, internally adjustable limit stops for maximum and minimum settings, a cover, and required mounting and connection accessories.
 - 2.3.15.2 Pneumatic humidistats are to be 2 pipe type and complete with plug-in air connections.
 - 2.3.15.3 Electric humidistats are to be line voltage (115 volt), or 24 volt electronic type.
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- 2.3.15.4 Wall mounting humidistats are to be complete with a tamper-proof display type cover.
- 2.3.15.5 Duct mounting humidistats are to be complete with a display type cover, duct sampling chamber with 300 mm (12") long extruded pick-up tube for duct mounting, a moulded mounting base, and a ventilated cover.
- 2.3.16 Hardware to permit building automation system control and monitoring of input/output points in accordance with Section 25 05 02 – Building Automation System, points schedule, and drawing control diagrams and operation sequences. All such hardware is to be suitable in all respects for interface with the building automation system.

2.4 SYSTEM WIRING MATERIALS

- 2.4.1 System wiring, conduit, boxes, and similar materials are to be in accordance with requirements specified in appropriate Section(s) of Electrical Work specification.

2.5 AIR COMPRESSOR SET AND ACCESSORIES

- 2.5.1 Package type, duplex, receiver mounted, automatic, CSA certified air compressor set selected to meet all requirements of control system while operating not more than 33% of the time with a maximum of 6 starts per hour. Compressor set complete with a low resistance air intake filter/silencer, and motors and V-belt drives with guards in accordance with requirements of Section 20 05 00 – Common Work Results for Mechanical, and following:
 - 2.5.1.1 suitably sized, ASME rated and stamped steel receiver in accordance with CSA B51 and Provincial requirements with support feet, rubber-steel-rubber type vibration isolation pads, automatic tank drain, adjustable pressure switch, safety relief valve, check valve, self-lubricating ball type outlet valve, manual drain valve, and a flexible tank to air piping flexible connection supplied loose for site installation;
 - 2.5.1.2 separate (supplied loose) surface wall mounting starter and control panel factory pre-wired for single point site connection of electric power, complete with NEMA 2 enclosure, door interlock disconnect switch, a fused overload protected magnetic starter for each motor, control transformer, 2 NO and 2 NC auxiliary contacts, a green "power on" LED and a white LED for each working compressor, and an alternator to automatically alternate the working compressor after each start and to automatically start lag compressor if working compressor fails;
 - 2.5.1.3 packaged type refrigerated air dryer sized to suit and supplied loose for site installation, complete with hot gas by-pass to maintain continuous operation and stable dew point, power on and high temperature indicating lights, overload protected motor starter, an integral automatic condensate drain trap, and a manual 3-valve by-pass to permit removal of heat exchanger for servicing without disrupting control system;
 - 2.5.1.4 coalescing type oil removal filter supplied loose by compressor set manufacturer for site installation, sized to control air piping main size, and equipped with automatic drain and an indicator piping kit for media maintenance inspection.
- 2.5.2 Acceptable manufacturers are:
 - 2.5.2.1 DeVilbiss (Canada) Ltd.;
 - 2.5.2.2 Compair Kellog;
 - 2.5.2.3 Atlas Copco Compressors Canada.

2.6 CONTROL AIR FILTER AND PRV ASSEMBLIES

- 2.6.1 Combination filter/PRV assembly with quantities to suit control system capacity requirements, each assembly complete with:

- 2.6.1.1 oil/particle filter with drain port and replaceable coalescing filter element in a transparent polycarbonate bowl with perforated metal shield;
- 2.6.1.2 adjustable pressure reducing valve with inlet and outlet pressure gauges and outlet safety pressure relief valve;
- 2.6.1.3 wall mounting bracket.
- 2.6.2 Each filter is to remove both 0.08 micron diameter particles and 0.01 micron diameter oil aerosol, and filter elements are to be removable without disconnecting any piping.

2.7 CONTROL AIR PIPING AND TUBING

- 2.7.1 High pressure piping mains are to be Type M hard drawn seamless copper with forged copper soldering type fittings and 95% tin / 5% Antimony solder joints.
- 2.7.2 Low pressure tubing is to be:
 - 2.7.2.1 seamless hard drawn phosphorized copper tubing with proper soldering type copper fittings and 50% lead / 50% tin solder joints;
 - 2.7.2.2 annealed soft copper with Garlock compression fittings;
- 2.7.3 type "FR" plenum rated flame retardant polyethylene control tubing, single, twin or bundled as required, and colour coded.

3 EXECUTION

3.1 GENERAL RE: INSTALLATION OF CONTROLS

- 3.1.1 Provide complete systems of control and instrumentation to control and supervise building equipment and systems in accordance with this Section and drawings.
- 3.1.2 Control systems are to generally be as indicated on drawing control diagrams and are to have all the elements therein indicated or implied.
- 3.1.3 Control diagrams show only the principal components controlling the equipment and systems. Supplement each control system with all relays, transformers, sensors, etc., required to enable each system to perform as specified and to permit proper operation and supervision.
- 3.1.4 Brace and secure control system equipment in accordance with requirements specified in Section 20 05 48.16 – Seismic Controls for Mechanical Systems.

3.2 INSTALLATION OF CONTROL AIR PIPING AND TUBING

- 3.2.1 Provide required control air piping and tubing.
 - 3.2.2 Connect new control air piping/tubing to existing pneumatic control air supply.
 - 3.2.3 Piping/tubing is to be as follows:
 - 3.2.3.1 for piping mains and branches, type "M" seamless copper;
 - 3.2.3.2 for exposed connections to control components, hard or soft copper tubing;
 - 3.2.3.3 for tubing in accessible ceiling spaces, plenum rated polyethylene, neatly bundled with plastic ties and properly supported;
 - 3.2.3.4 for connections to control components within control cabinets, soft copper or plenum rated polyethylene tubing.
 - 3.2.4 Properly install and support piping and tubing. Provide suitably sized trap legs with drain valves at all low points to prevent condensation pockets.
 - 3.2.5 Solder all copper joints except at instruments or panels where compression fittings are to be used.
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3.3 SUPPLY OF CONTROL AIR DAMPERS AND OPERATORS

- 3.3.1 Unless otherwise specified, supply required control dampers. Hand dampers to sheet metal trade at site in location where they are required for installation as part of sheet metal work. Ensure each damper is correctly located and mounted.
- 3.3.2 Unless otherwise specified or scheduled, insulated dampers to be provided for all outdoor air intake and exhaust air applications.
- 3.3.3 Provide linkage and operators for dampers. Wherever possible locate damper operators so they are accessible from outside duct, plenum, and equipment casings. Bracket mount operators on ducts or plenums clear of insulation where applicable.
- 3.3.4 Where sequence operation is indicated, or where multiple operators drive a series of dampers, provide pilot positioners to couple their action.
- 3.3.5 Ensure dampers located in ductwork other than galvanized steel are constructed of type 316 stainless steel.

3.4 SUPPLY OF AUTOMATIC CONTROL VALVES AND OPERATORS

- 3.4.1 Unless otherwise specified, supply required automatic control valves. Hand valves to appropriate piping trades at site in locations they are required for installation as part of piping work. Ensure each valve is properly located and installed.
- 3.4.2 Provide an operator for each valve.

3.5 INSTALLATION OF THERMOSTATS

- 3.5.1 Unless otherwise noted, provide required thermostats.
- 3.5.2 Provide a ventilated clear acrylic cover for each thermostat located in finished areas, and a wire type guard for each thermostat located in unfinished areas and in areas such as mechanical rooms where thermostat is subject to damage.
- 3.5.3 Unless otherwise indicated, mount room thermostats 1.5 m (5 ft.) above finished floor level. Thermostats intended to be used by building occupants in a barrier-free path of travel to be mounted at 1.2 m. Confirm exact location of all thermostats prior to roughing-in.
- 3.5.4 Provide stand-off mounting and an insulated sub-base for thermostats on outside walls.
- 3.5.5 Perform control wiring associated with installation of electric or electric-electronic thermostats.

3.6 INSTALLATION OF CONTROL SYSTEM COMPONENTS

- 3.6.1 Provide required control system components and related hardware. Refer to drawing control diagrams and sequences.
- 3.6.2 Where components are pipe, duct, or equipment mounted supply components at proper time, coordinate installation with appropriate trade, and ensure components are properly located and mounted.

3.7 CONTROL WIRING

- 3.7.1 Perform required control wiring work for control systems except:
 - 3.7.1.1 power wiring connections to equipment and panels, except as noted below;
 - 3.7.1.2 control wiring associated with mechanical plant equipment and systems whose control is not part of work specified in this Section;
 - 3.7.1.3 starter interlock wiring.
- 3.7.2 Except as specified below, install wiring in conduit. Unless otherwise specified, final 600 mm (2') connections to sensors and transmitters, and wherever conduit extends across flexible duct connections is to be liquid-tight flexible conduit.

- 3.7.3 Control wiring in ceiling spaces and wall cavities may be plenum rated cable installed without conduit but neatly harnessed, secured, and identified.
- 3.7.4 Wiring work is to be in accordance with certified wiring schematics and instructions, and wiring standards specified in appropriate Sections of Electrical Work Specification.

3.8 *INSTALLATION OF CONTROL AIR COMPRESSOR SET AND DRYER*

- 3.8.1 Provide a duplex air compressor set. Secure set in place on vibration isolation on a concrete housekeeping pad. Install flexible piping connections supplied with set and connect with required piping, including drain piping extended and terminated at nearest drain.
- 3.8.2 Wall mount power and control panel(s) adjacent to equipment. Connect compressor set panel pressure switch with copper tubing to compressor set.

3.9 *IDENTIFICATION AND LABELLING OF EQUIPMENT AND CIRCUITS*

- 3.9.1 Refer to identification requirements specified in Section 20 05 00 – Common Work Results for Mechanical.
- 3.9.2 Identify equipment as follows:
 - 3.9.2.1 enclosures and components: engraved laminated nameplates with wording listed and approved prior to manufacture of nameplates;
 - 3.9.2.2 wiring: numbered sleeves or plastic rings at both ends of conductor, with numbering corresponding to conductor identification on shop drawings and "as-built" record drawings.

3.10 *TESTING, ADJUSTING, CERTIFICATION, START-UP, AND TRAINING*

- 3.10.1 When control work is complete, check installation of components and wiring connections, make any required adjustments, and coordinate adjustments with personnel doing HVAC testing, adjusting and balancing work.
- 3.10.2 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.10.3 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.10.4 Include for 2 full, 8 hour days on-site operation demonstration and training sessions. Training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.
- 3.10.5 Include for 2 follow-up site training and troubleshooting visits, one 6 months after Substantial Completion and other at end of warranty period, both when arranged by Owner and for a full, 8 hour day to provide additional system training as required, and to demonstrate troubleshooting procedures.

END OF SECTION

1 GENERAL

1.1 ABBREVIATIONS AND DEFINITIONS

1.1.1 Abbreviations used in this Specification are as follows:

- 1.1.1.1 BAS building automation system;
- 1.1.1.2 DDC direct digital controls;
- 1.1.1.3 LAN local area network;
- 1.1.1.4 PC personal computer.

1.2 SUBMITTALS

1.2.1 Submit shop drawings/product data sheets for BAS components. As a minimum, submit the following:

- 1.2.1.1 BAS network architecture, including modes and interconnections;
- 1.2.1.2 systems schematics, sequences, and flow diagrams;
- 1.2.1.3 points schedule for each point in BAS, including point type, object name, expanded ID, display units, controller type, and address;
- 1.2.1.4 samples of graphic display screen types and associated menus;
- 1.2.1.5 detailed Bill of Materials for each system or application, identifying quantities, part numbers, descriptions, and optional features;
- 1.2.1.6 control damper schedule including a separate line for each damper and a column for each of damper attributes including code number, fail position, damper type, damper operator, duct size, damper size, mounting and actuator type;
- 1.2.1.7 control valve schedules including a separate line for each valve and a column for valves as for control dampers;
- 1.2.1.8 room schedule including a separate line for each HVAC terminal unit indicating type, location and address;
- 1.2.1.9 details of BAS interfaces and connections to other systems;
- 1.2.1.10 product data sheets or marked catalogue pages including part number, photograph and description for BAS hardware and software.

1.3 CLOSEOUT SUBMITTALS

1.3.1 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.

1.3.2 Record "as-built" drawings are to include:

- 1.3.2.1 schematic outline of BAS for quick reference of overall system scope;
- 1.3.2.2 adequate record of work as installed, including locations and routing of system wiring.

1.3.3 O&M Manual is to include:

- 1.3.3.1 hardware specification manual which gives a functional description of hardware components;
- 1.3.3.2 operator's manual which outlines concise instructions for operation of system and an explanation and recovery route for system alarms;
- 1.3.3.3 engineering manual which outlines and defines system set-up, definition and application;
- 1.3.3.4 data manual which indicates applications data programmed into system;
- 1.3.3.5 system software documentation.

1.4 DESCRIPTION OF THE BUILDING AUTOMATION SYSTEM

1.4.1 Building automation system is to consist of a modular, BACnet protocol, open architecture system incorporating direct digital control and monitoring of equipment and systems and consisting of all hardware and software required for complete, functional

DDC control system. BAS is to be accessible through standard personal computers within building through a wireless application protocol device, or remotely through Internet by means of a standard web browser.

- 1.4.2 BAS is to be field expandable, with a distributed architectural design to eliminate dependence upon any single device for alarm reporting and control execution. Failure of any single component or network connection is not to interrupt execution of control strategies at other operational devices. BAS is to maintain all settings and overrides through a system re-boot, and is to incorporate, as a minimum, following integrated features, functions and services:
 - 1.4.2.1 graphic user interface for accessing and viewing BAS information, commanding points, changing setpoints, responding to alarms, programming time-of-day schedules;
 - 1.4.2.2 operator information, alarm management, and control features;
 - 1.4.2.3 enterprise-level information and control access;
 - 1.4.2.4 information management including monitoring, transmission, archiving, retrieval, and reporting functions;
 - 1.4.2.5 diagnostic monitoring and reporting of BAS functions;
 - 1.4.2.6 off-site monitoring and management access;
 - 1.4.2.7 energy management;
 - 1.4.2.8 standard applications for terminal HVAC systems.
- 1.4.3 BAS is to include, but not be limited to, following:
 - 1.4.3.1 personal computer based server for networking and integrating all hardware components into a single BAS;
 - 1.4.3.2 personal computer based operator work station with colour monitor for colour graphic displays, and a colour printer;
 - 1.4.3.3 portable operator's terminal;
 - 1.4.3.4 network of standalone network automation engine(s);
 - 1.4.3.5 network of field equipment controllers;
 - 1.4.3.6 input/output modules;
 - 1.4.3.7 local display devices;
 - 1.4.3.8 distributed user interfaces;
 - 1.4.3.9 network processing, data storage and communication equipment;
 - 1.4.3.10 all other components required for a complete and operating BAS.

1.5 QUALITY ASSURANCE

- 1.5.1 BAS hardware and software is to be installed by experienced personnel employed and trained by manufacturer/supplier of field equipment controllers. System wiring is to be installed by journeyman electricians or under direct on-site supervision of journeyman electricians.

2 PRODUCTS

2.1 GENERAL RE: BUILDING AUTOMATION SYSTEM

- 2.1.1 Control system components (field devices) other than those specified in this Section are generally specified in Section 25 05 01 – Automatic Control Systems. Components factory installed with equipment or supplied with equipment are specified in mechanical work Sections with equipment.
- 2.1.2 BAS specified in this Section is an expandable DDC building automation system in accordance with drawing control diagrams and sequences, and points lists.
- 2.1.3 Manufacturers:
 - 2.1.3.1 Johnson Controls Inc.;
 - 2.1.3.2 Siemens Building Technologies Inc.;

- 2.1.3.3 Honeywell International Inc.;
- 2.1.3.4 Trane Controls;
- 2.1.3.5 Distech Controls;
- 2.1.3.6 Delta Controls;
- 2.1.3.7 Schneider Electric;
- 2.1.3.8 Alerton.

2.2 BAS ARCHITECTURE

- 2.2.1 BAS is to be based industry standard Ethernet TCP/IP communications protocol. Where used, LAN controller cards are to be standard "off-the-shelf" products available through normal PC vendor channels. BAS is to be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication. BAS is to be compatible with other enterprise-wide networks, and where indicated, BAS is to be connected to the enterprise network and share resources with it by way of standard networking devices and practices.
- 2.2.2 Network automation engines are to provide supervisory control over control network and are to support BACnet Standard MS/TP bus communication protocol (ASHRAE SSPP-135, Clause 9). Control networks are to provide either a "peer-to-peer", master-slave, or supervised token passing communications and are to operate at a minimum communication speed of 9600 baud. DDC controllers are to reside on control network.
- 2.2.3 BAS is to include appropriate hardware and software to allow BACnet bi-directional data communications between BAS and building equipment/system control panels. BAS is to receive, react to, and return information from connected equipment and systems. Data required by application is to be mapped into automation engine's data base and is to be transparent to operator. Point inputs and outputs from building equipment/system control panels is to have real-time interoperability with BAS software features such as control software, energy management, custom process programming, alarm management, historical data and trend analysis, totalization, and local area network communications.

2.3 DEDICATED WEB BASED USER INTERFACE

- 2.3.1 User interface is to be web based and is to operate on a personal computer for command entry, information management, network alarm management, and database management functions. Real-time control functions including scheduling, history collection, and alarming are to be resident in appropriate components of BAS network to facilitate greater fault tolerance, availability and reliability.
- 2.3.2 Architecture of personal computer is to be implemented to conform to industry standards such that it can accommodate applications provided with BAS and mechanical systems and equipment, including but not limited to Microsoft Office Applications. Specifically, it must conform to following interface standards:
 - 2.3.2.1 Microsoft Edge (or other standard browser) for user interface functions;
 - 2.3.2.2 Microsoft Office Professional for creations, modification and maintenance of reports, and sequencing other necessary building management functions;
 - 2.3.2.3 Microsoft Outlook or other email program for supplemental alarm functionality and communication of system events, and reports;
 - 2.3.2.4 required network operating system for exchange of data and network functions such as printing of reports, trends, and specific system summaries.
- 2.3.3 Personal computer server or operator workstation is to be configured at minimum as follows:
 - 2.3.3.1 memory: 8 GB;
 - 2.3.3.2 processor: Intel;
 - 2.3.3.3 hard drive: 500 GB free hard drive;
 - 2.3.3.4 graphics card: 1 GB DDR3;
 - 2.3.3.5 ports: 1 HDMI, 2 serial, one parallel, and 2 USB-C ports;

- 2.3.3.6 keyboard: 101 keyboard and 2-button mouse;
- 2.3.3.7 monitors: 23" LCD monitor with 1920 x 1080 resolution;
- 2.3.3.8 LAN communications: 10/100/1000 network card.
- 2.3.4 Operating System Software: Windows 7 Professional 64-bit Microsoft SQL 2008 Server and SQL 2008 Server Express are automatically installed by EBI. Where user interface is not provided via browser, PC is to be equipped with a complete workstation software package including any software or hardware keys, and package is to include original installation discs and licenses for all software, device drivers, peripherals, and software registration cards which are to be handed to Owner.
- 2.3.5 Printer is to be at minimum equal to Hewlet Packard "DeskJet" colour printer with a speed of 600 DPI black and 300 DPI colour, and 64 K input print buffer.

2.4 DISTRIBUTED WEB BASED USER INTERFACE

- 2.4.1 Features and functions of dedicated web based user interface described above are to be available on any computer connected directly or via a wide area or virtual private network to BAS network, which conforms to the following specifications:
 - 2.4.1.1 software is to run on Microsoft Edge (or other standard browser);
 - 2.4.1.2 minimum hardware requirements are:
 - (1) 2 GB RAM;
 - (2) 2.0 GHz clock speed Pentium 4 microprocessor;
 - (3) 120 GB hard drive;
 - (4) keyboard with 83 keys minimum;
 - (5) SVGA 1024 x 768 resolution display with 64K colours and 16 bit colour depth;
 - (6) mouse or other pointing feature.

2.5 REMOTE ACCESS VIA SMART PHONE AND/OR TABLET DEVICES

- 2.5.1 Available with an operator interface designed for use on various modern smart phone devices with network connectivity with the follow features:
 - 2.5.1.1 Mobile user interface operating over standard TCP network connection, performing well down to standard mobile 3G speeds, and optimized to ensure very high performance across different network topologies.
 - 2.5.1.2 Solution written with HTML5 web standards and browser agnostic, not deploying or using ActiveX controls, nor requiring installation of Java Runtime engine.
 - 2.5.1.3 Mobile solution incorporating full scope of responsibilities of BAS operators for remote mobile users, allowing them to view or control points within their assigned facility locations.
 - 2.5.1.4 Without alternation, mobile user interface operable within any standard internet browser from a normal personal computer.
- 2.5.2 Along with optimized smart phone user interface, a dedicated tablet access user interface, optionally providing full operator workstation functionality, on a tablet style device. Tablet interface is to support standard operator workstation features including full operator scope of responsibility, and operable using commercial off-the-shelf technology.

2.6 USER INTERFACE APPLICATION COMPONENTS

- 2.6.1 Integrated browser based client application is to be used as user operator interface program. System is to employ an event-driven rather than a device polling methodology to dynamically capture and present new data to user. Additional features are as follows:
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- 2.6.1.1 inputs, outputs, set-points, and other parameters as defined in Part 3 of this Section, shown on drawings, or required as part of system software are to be displayed for operator viewing and modification from operator interface software;
 - 2.6.1.2 user interface software is to provide help menus and instructions for each operation and/or application;
 - 2.6.1.3 system is to support customization of user interface configuration and a home page for each operator;
 - 2.6.1.4 system is to support user preferences in alarm, trend, display, and applications screen presentations;
 - 2.6.1.5 controller software operating parameters are to be displayed for operator to view/modify from user interface, and these parameters are to include set-points, alarm limits, time delays, PID tuning constants, run times, point statistics, schedules, etc.;
 - 2.6.1.6 operator interface is to incorporate comprehensive support for functions including but not limited to following:
 - (1) user access for selective information retrieval and control command execution;
 - (2) monitoring and reporting;
 - (3) alarm, non-normal, and return to normal condition annunciation;
 - (4) selective operator override and other control actions;
 - (5) information archiving, manipulation, formatting, display and reporting;
 - (6) BAS internal performance supervision and diagnostics;
 - (7) on-line access to help menus;
 - (8) on-line access to current BAS as-built records and documentation;
 - (9) means for controlling, re-programming, and re-configuration of the BAS operation and for the manipulation of the BAS database information in compliance with applicable Codes and Regulations for individual BAS applications.
 - 2.6.1.7 system is to support a list of application programs configured by users that are called up by the Tools Menu, hyperlinks within graphic displays, and key sequences;
 - 2.6.1.8 operation of control system is to be independent of user interface, which is to be used for operator communication only.
 - 2.6.2 System is to have a minimum of 5 levels of nesting, and the capability of displaying multiple navigation trees to aid operator in navigating throughout all systems and points connected, adding custom trees, defining any logical grouping of points and arranging them on a tree in any order, and nesting groups within other groups. Navigation trees are to be "dockable" to other displays such as graphics, meaning trees will appear as part of display but can be detached and then minimized to Windows task bar or closed altogether, however, a simple keystroke will reattach navigation to primary display of user interface.
 - 2.6.3 Alarms are to be routed directly from network automation engines to PC's and servers, and it is to be possible for specific alarms from specific points to be routed to specific PC's and servers. BAS is to annunciate diagnostic alarms indicating system failures and non-normal operating conditions, annunciate application alarms as required by points lists and sequences, and as a minimum, permit 4 categories of alarm sounds customizable through user defined wav files. Alarm management segment of user interface is to provide, as a minimum, following alarm functions:
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- 2.6.3.1 log, date, and time of alarm occurrence;
 - 2.6.3.2 generate a "pop-up" window or populate a dedicate section of screen with audible alarm to inform a user that an alarm has been received;
 - 2.6.3.3 permit a user with the appropriate security level to acknowledge, temporarily silence, or discard an alarm;
 - 2.6.3.4 provide an audit trail on PC hard drive for alarms by recording user acknowledgement, deletion or disabling of an alarm, name of the user, alarm, action taken, and time/date of alarm;
 - 2.6.3.5 facilitate ability to direct alarms to an email address or alphanumeric pager, in addition to pop-up window described above;
 - 2.6.3.6 any attribute of any object in system may be designated to report an alarm.
 - 2.6.4 Reports and summaries are to be generated and directed to user interface displays with subsequent assignment to printers or discs. Summaries and reports are to be accessible via standard user interface functions, and selection of a single menu item, tool bar item, or tool bar button is to print any displayed report or summary. System is to permit creation of custom reports and queries via a standard web services XML (Extensible Mark-up Language) interface and commercial of-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports. As a minimum, BAS is to provide following reports and summaries:
 - 2.6.4.1 all points in BAS;
 - 2.6.4.2 all points in each BAS application;
 - 2.6.4.3 all points in a specific controller;
 - 2.6.4.4 all points in a user-defined group of points;
 - 2.6.4.5 all points currently in alarm;
 - 2.6.4.6 all points locked out;
 - 2.6.4.7 all BAS schedules;
 - 2.6.4.8 all user defined and adjustable variables, schedules, interlocks, etc.
 - 2.6.5 Graphical display for time-of-day scheduling and override scheduling of building operations is to be provided, with weekly schedules for each group of equipment with a specific time use schedule, and it is to be possible to define one or more exception schedules for each schedule including reference to calendars, with monthly calendars provided to permit simplified scheduling of holidays and special days for a minimum of 5 years in advance, user selected with the pointing device or keyboard. Changes to schedules made from user interface are to directly modify network automation engine schedule database. Selection of a single menu item or tool bar button is to print any displayed schedule. As a minimum, following functions are to be provided:
 - 2.6.5.1 weekly schedules;
 - 2.6.5.2 exception schedules;
 - 2.6.5.3 monthly calendars;
 - 2.6.5.4 global schedules.
 - 2.6.6 BAS is to be complete with multiple-level password access protection to permit user/manager to user interface control and display, database manipulation capabilities deemed appropriate for each user, based on an assigned password. Password access protection features are to include:
 - 2.6.6.1 each user is to have a user name (24 characters minimum), a password (12 characters minimum), and access levels;
 - 2.6.6.2 each user may change his or her password at any time;
 - 2.6.6.3 when editing or entering passwords, system is not to echo actual characters for display on monitor;
 - 2.6.6.4 minimum of 500 unique password is to be supported;
 - 2.6.6.5 operators are to be able to perform only those commands available for their respective passwords, and display of menu selections is to be limited to only those items defined for access level assigned to password of each user;
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- 2.6.6.6 BAS is to automatically generate a report of log-on/log-off and system activity for each user, and any action that results in a change in operation or configuration of control system is to be recorded, including acknowledgement and deletion of alarms;
 - 2.6.6.7 minimum of 5 levels of access is to be supported individually or in any combination of following:
 - (1) Level 1 – view data;
 - (2) Level 2 – command;
 - (3) Level 3 – operator overrides;
 - (4) Level 4 – database modification;
 - (5) Level 5 – database configuration;
 - (6) Level 6 – all privileges including password add/modify.
 - 2.6.7 User interface is to be equipped with screen management capabilities that allows user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network of user defined navigation trees.
 - 2.6.8 Graphics application program is to be an integral part of user interface and is to include a create/edit function and a runtime function, and system architecture is to support a number of graphic documents (graphic definition files) limited only by memory and computing resources to be generated and executed. Graphics are to be capable of displaying and providing animation based on real-time data that is acquired, derived, or entered. Additional features include following:
 - 2.6.8.1 maximum of 16 graphic applications are to be able to be executed at any one time on a user interface or workstation with 4 visible to user, and each graphic application is to be capable of following functions:
 - (1) all graphics are to be fully scalable;
 - (2) graphics are to support a maintained aspect ratio;
 - (3) multiple fonts are to be supported;
 - (4) unique background is to be assigned on a per graphic basis;
 - (5) colour of animations and values on displays is to indicate status of object attribute.
 - 2.6.8.2 it is to be possible to change values (set-points) and states in system controlled equipment by using drop-down windows accessible via pointing device;
 - 2.6.8.3 graphic editing tool is to be provided to permit creation and editing of graphic files, and graphic editor is to be capable of performing/defining animations, defining runtime binding, and:
 - (1) in general, facilitate creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required;
 - (2) be capable of adding additional content to any graphic by importing backgrounds in the SVG, BMP, or JPG file formats.
 - 2.6.8.4 many graphic displays representing part of building and various building components are exact duplicates, with exception that various variables are bound to different field values, consequently, it is to be possible to bind value of a graphic display to aliases, as opposed to physical field tags.
 - 2.6.9 Trend and change of value data is to be stored within the automation engines or server and uploaded to a dedicated trend database or exported in a selectable data format via a data export utility. Uploads to a dedicated database are to occur based on one of user-defined interval, manual command, or when trend buffers are full. Exports are to be as
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requested by user or on a time scheduled basis. System is to be equipped with a configurable data storage sub-system for collection of historical data which can be stored in either Microsoft Access or SQL database format. Each automation engine is to store, trend, and point history data for analog and digital inputs and outputs as follows:

- 2.6.9.1 any point, physical or calculated, may be designated for trending, and methods of collection are to be defined time interval or a change of value;
 - 2.6.9.2 each automation engine or server is to be capable of storing multiple samples for each physical point and software variable based on available memory, including an individual sample time/date stamp, and points may be assigned to multiple history trends with different collection parameters.
 - 2.6.10 Trend viewing utility with access to data points and capability of defining trend study displays to include multiple trends is to be provided, and is to include:
 - 2.6.10.1 capability of retrieving any historical database point for use in displays and reports by specifying point name and associated trend name;
 - 2.6.10.2 displays which are able to be single or stacked graphs with on-line selectable display characteristics such as ranging, colour, and plot style;
 - 2.6.10.3 display magnitude (zoom capability) and units selectable by operator at any time without reconfiguration of processing or collection of data;
 - 2.6.10.4 display magnitude is to be automatically scaled to show full graphic resolution of data being displayed;
 - 2.6.10.5 trend studies are to be capable of calculating and displaying calculated variables including highest value, lowest value, and time based;
 - 2.6.10.6 display is to support user's ability to change colours, sample sizes, and types of markers.
 - 2.6.11 BAS is to be equipped with a database manager that separates database monitoring and management functions by supporting 2 separate windows. Database secure access is to be accomplished using standard SQL authentication including ability to access data for use outside of BAS application. Additional features are as follows:
 - 2.6.11.1 database management function is to include summarized information on trend, alarm, event, and audit for backup, purge, and restore database management functions;
 - 2.6.11.2 database manager is to support 4 tabs as follows:
 - (1) statistics, which is to display database server information and trend, alarm (event), and audit information on BAS database;
 - (2) maintenance, which is to be an easy method of purging records from BAS server trend, alarm (event), and audit databases by supporting separate screens for creating a backup prior to purging, selecting database, and allowing for retention of a selected number of day's data;
 - (3) backup, which is to provide means to create a database backup file and select a storage location;
 - (4) restore, which is to provide a restricted means of restoring a database by requiring user to log into an Expert Mode in order to view Restore screen.
 - 2.6.11.3 status bar is to appear at bottom of BAS database manager tabs and is to indicate information on current display activity with icons as follows:
 - (1) Ready;
 - (2) Purging Record From Database;
 - (3) Action Failed;
 - (4) Refreshing Statistics;
 - (5) Restoring Database;
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- (6) Shrinking A Database;
 - (7) Backing-Up A Database;
 - (8) Resetting Internet Information Services;
 - (9) Shutting Down BAS Deice Manager;
 - (10) Action Successful.
- 2.6.11.4 database manager monitoring functions are to be accessed through Monitoring Settings window and are to continuously read database information once user has logged in;
- 2.6.11.5 system is to advise user via task bar icons and email messages when a database value has exceeded a warning or alarm limit;
- 2.6.11.6 Monitoring Settings window is to have following sections:
- (1) General: allow user to set and review scan intervals and start times;
 - (2) Email: allow user to create and review email and telephone text messages to be delivered when a warning or alarm is generated;
 - (3) Warning: allow user to define warning limit parameters, set reminder frequency, and link email message;
 - (4) Alarm: allow user to define alarm limit parameters, set reminder frequency, and link email message;
 - (5) Database Login: protect system from unauthorized database manipulation by creating a read access and write access for each trend, alarm (event), and audit databases as well as an Expert Mode required to restore a database.
- 2.6.11.7 Monitoring Settings taskbars to display following informational icons:
- (1) Normal: indicates by colour and size that databases are within their limits;
 - (2) Warning: indicates by colour and size that one or more databases have exceeded their warning limit;
 - (3) Alarm: which indicates by colour and size that one or more databases have exceeded their alarm limit.
- 2.6.11.8 BAS is to indicate via taskbar icons and email messages when a database value has exceeded a warning or alarm limit;
- 2.6.12 BAS is to be equipped with a demand limiting and load rolling program for purpose of limiting peak energy usage and reducing overall energy consumption. Program is to support both Sliding Window and Fixed Window methods of predicting demand. Additional features are as follows:
- 2.6.12.1 system is to support 3 levels of sensitivity in Sliding Window demand calculations for fine tuning the system, as follows:
- (1) Low Setting: sheds loads later and over shortest period of time and maximizes period of time equipment is on;
 - (2) Medium Setting: sheds loads earlier over a period of time greater than Low Setting, and increases time equipment is on and decreases probability of exceeding "Tariff Target";
 - (3) High Setting: sheds loads earlier and over a longer period of time than Medium Setting to minimize probability of exceeding "Tariff Target".
- 2.6.12.2 system is to have both a Shed Mode and a Monitor Only Mode of operation, as follows:
- (1) when Shed Mode is engaged, system is to actively control demand;
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- (2) when Monitor Mode is engaged, system is to simulate shedding action but will not take any action.
 - 2.6.12.3 Demand Limiting Program is to monitor energy consumption rate and compare it to a user defined "Tariff Target", and maintain consumption below target by selectively shedding loads based on a user defined strategy;
 - 2.6.12.4 Demand Limiting Program is to be capable of supporting a minimum of 10 separate load priorities, with each load user assigned, and a minimum of 12 separate "Tariff Targets" defining maximum allowed average power usage during current interval;
 - 2.6.12.5 system is to support a maximum shed time for each load as determined by user, and system is to restore load before maximum shed time has expired;
 - 2.6.12.6 system is to support a minimum shed time for each load as determined by user, and system is not to restore load before minimum shed time has expired;
 - 2.6.12.7 system is to support a minimum release time for each load as determined by user, and system is not to shed load until it has been off for minimum release time;
 - 2.6.12.8 system is to support three user defined options if meter does not function properly, as follows:
 - (1) shedding – currently shed loads will be released as their maximum shed time expires;
 - (2) maintain current shed rate – system will use demand limiting shed rate that was present when meter began to function improperly;
 - (3) use unreliable meter shed rate – system is to control to a user defined unreliable shed rate target.
 - 2.6.12.9 Load Rolling Program is to sum the loads currently shed and compare sum to a user defined load rolling target, and system is to maintain consumption below target by selectively shedding loads based on a user defined load priority;
 - 2.6.12.10 Load Rolling Program is to be capable of supporting a minimum of 10 separate load priorities with each load user defined to a load priority;
 - 2.6.12.11 Load Rolling Program is to be capable of supporting a minimum of 12 separate "Tariff Targets" defining amount of energy by which demand must be reduced;
 - 2.6.12.12 system is to equip user with a Load Tab that displays all demand limiting and load rolling parameters for any selected load;
 - 2.6.12.13 system is to be complete with a Load Summary that displays all loads associated with demand limiting and load rolling program, and status icons for each load are to indicate:
 - (1) Load Is Offline;
 - (2) Load Is Disabled;
 - (3) Load Is Shed;
 - (4) Load Is Locked;
 - (5) Load Is In Comfort Override.
 - 2.6.12.14 Load Summary is to include a load summary runtime view listing following load conditions:
 - (1) Load Priority;
 - (2) Shed Strategy;
 - (3) Load Rating;
 - (4) Present Value;
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- (5) Ineligible Status;
- (6) Active Timer;
- (7) Time Remaining;
- (8) Last Shed time.

2.7 NETWORK AUTOMATION ENGINES

- 2.7.1 Network automation engines are to be ULC listed and labelled, BACnet Testing Labs (BTL) certified and labelled, fully user programmable supervisory controllers to monitor a network of a minimum of 100 distributed application-specific controllers for a global strategy and direction and to communicate on a peer-to-peer basis with other network automation engines.
 - 2.7.2 Each network automation engine is to have ability to deliver a web based user interface as specified above, and computers connected physically or virtually to automation network are to have access to web-based user interface. Additional characteristics/requirements are as follows:
 - 2.7.2.1 web-based user interface software is to be imbedded in each network automation engine;
 - 2.7.2.2 each network automation engine is to support a minimum of 4 concurrent users;
 - 2.7.2.3 user is to be capable of accessing all system data through one network automation engine;
 - 2.7.2.4 remote users connected to network through an internet service provider or by telephone dial-up are also to have total system access through one network automation engine;
 - 2.7.2.5 each network automation engine is to be capable of generating web-based user interface graphics, and this capability is to be imbedded in network automation engine;
 - 2.7.2.6 user interface is to support following functions using a standard version of Microsoft Edge:
 - (1) configuration;
 - (2) commissioning;
 - (3) data archiving;
 - (4) monitoring;
 - (5) commanding;
 - (6) system diagnostics.
 - 2.7.2.7 each network automation engine is to permit temporary use of portable devices without interrupting normal operation of permanently connected modems.
 - 2.7.3 Each network automation engine is to be a multi-tasking, multi-user, microprocessor-based real time digital control processor sized to meet requirements of system with a minimum word size of 32 bits, and standard operating systems.
 - 2.7.4 Each network automation engine is to have sufficient memory to support its own operating system, databases, and control programs to provide supervisory control for control level devices.
 - 2.7.5 Each network automation engine is to include an integrated, hardware based real time clock.
 - 2.7.6 Each network automation engine is to be equipped with LED indicators to identify following conditions:
 - 2.7.6.1 Power, On/Off;
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- 2.7.6.2 Ethernet Traffic, Ethernet Traffic/No Ethernet Traffic;
- 2.7.6.3 Ethernet Connection Speed, 10 Mbps/100 Mbps;
- 2.7.6.4 FC Bus A, Normal Communications/No Field Communications;
- 2.7.6.5 FC Bus B, Normal Communications/No Field Communications;
- 2.7.6.6 Peer Communication, Data Traffic Between Network Automation Engines;
- 2.7.6.7 Run, NAE Running/NAE in Start-up/NAE Shutting Down/Software Not Running;
- 2.7.6.8 Battery Fault, Battery Defective/Data Protection Battery Not Installed;
- 2.7.6.9 24 VAC, 24 VAC Present/Loss of 24 VAC;
- 2.7.6.10 Fault, General Fault;
- 2.7.6.11 Modem RX, NAE Modem Receiving Data;
- 2.7.6.12 Modem TX, NAE Modem Transmitting Data.
- 2.7.7 Each network automation engine is to be equipped with ports for operation of operator input/output devices such as industry standard computers, modems, and portable operator's terminals. Ports are to be as follows:
 - 2.7.7.1 2 USB ports;
 - 2.7.7.2 2 URS-232 serial data communication ports;
 - 2.7.7.3 2 RS-485 ports;
 - 2.7.7.4 one Ethernet port.
- 2.7.8 Each network automation engine is to continually perform self-diagnostics, communications diagnostics, and diagnostics of all pane components, and transmit both local and remote annunciation of any detected component failure, low battery condition, and repeated failures to establish communication.
- 2.7.9 In event of loss of normal power each network automation engine is to continue to operate for a user adjustable period of up to 10 minutes after which there is to be an orderly shut-down of all programs to prevent loss of database or operating system software, and:
 - 2.7.9.1 during a loss of normal power, control sequences are to go to normal system shutdown conditions, and critical configuration data is to be saved into Flash memory;
 - 2.7.9.2 upon restoration of normal power and after a minimum off-time delay, controller is to automatically resume full operation through a normal soft-start sequence without manual intervention.

2.8 FIELD EQUIPMENT CONTROLLERS

- 2.8.1 Each field equipment controller is to be a fully user programmable BACnet Testing Labs (BTL) certified and labelled digital controller that communicates via BACnet MS/TP protocol. Each controller is to be housed in a plenum rated plastic housing with removable base to permit pre-wiring of analog and binary input/output field points without controller in place.
- 2.8.2 Each controller is to employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences, and is to be factory programmed with a continuous adaptive tuning algorithm that sense changes in physical environment and continually adjusts loop tuning parameters appropriately.
- 2.8.3 Each field equipment controller is to:
 - 2.8.3.1 include troubleshooting LED's to identify following conditions:
 - (1) Power On;
 - (2) Power Off;
 - (3) Download or Start-Up In Progress-Not Ready For Normal Operation;
 - (4) No Faults;
 - (5) Device Fault;

- (6) Field Controller Bus-Normal Data Transmission;
 - (7) Field Controller Bus-No Data Transmission;
 - (8) Field Controller Bus-No Communication;
 - (9) Sensor Actuator Bus-Normal Data Transmission;
 - (10) Sensor Actuator Bus-No Data Transmission;
 - (11) Sensor Actuator Bus-No Communication.
- 2.8.3.2 support universal inputs, configured to monitor any of following:
- (1) analog input, voltage mode;
 - (2) analog output, current mode;
 - (3) analog input, resistive mode;
 - (4) binary input, dry contact maintained mode;
 - (5) binary input, pulse counter mode.
- 2.8.3.3 support binary inputs configured to monitor either of following:
- (1) dry contact maintained mode;
 - (2) pulse counter mode.
- 2.8.3.4 support analog outputs configured to output either of following:
- (1) analog output, voltage mode;
 - (2) analog output, current mode.
- 2.8.3.5 support binary outputs, 24 VAC Triac;
- 2.8.3.6 support configurable outputs capable of following:
- (1) analog output, voltage mode;
 - (2) binary output mode.
- 2.8.3.7 have ability to reside on a master-slave/token-passing field controller bus supporting BACnet standard protocol as follows:
- (1) support communications, including input/output communications between field controllers and network automation engines;
 - (2) support a minimum of one hundred input/output modules and field equipment controllers in any combination;
 - (3) operate at a maximum distance of 4560 m (15,000 ft) between field controller and furthest connected device.
- 2.8.3.8 have ability to monitor and control a network of sensors and actuators over a master-slave/token-passing sensor-actuator bus supporting BACnet standard protocol as follows:
- (1) bus is to support a minimum of ten devices per trunk;
 - (2) bus is to operate at a maximum distance of 365 m (1200 ft) between field controller and furthest connected device.
- 2.8.3.9 capability of executing complex control sequences involving direct wired input/output points as well as input and output devices communicating over field controller bus or sensor-actuator bus;
- 2.8.3.10 support, but not limited to, following:
- (1) hot water, chilled water/central plant applications;
 - (2) custom air handling units for special applications;
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- (3) terminal units;
 - (4) special programs as required for systems control.
- 2.8.3.11 support a password protected local controller LCD back-lit display with 6 key keypad as an integral part of field controller or as a remote device communicating over sensor-actuator bus to permit user to view monitored points without logging into system, and to view and change set-points, modes of operation, and parameters.

2.9 INPUT/OUTPUT MODULES

- 2.9.1 Input/output modules to facilitate additional inputs and outputs for use in field equipment controllers are to be similar to field equipment controllers but less display and with a minimum of 4 and a maximum of 17 points.

2.10 SYSTEM CONFIGURATION TOOLS

- 2.10.1 System configuration tool is a software package supplied with BAS to enable a computer platform to be used as a stand-alone engineering configuration tool for a network automation engine and to permit programming of field equipment controllers. Configuration tool is to provide an archive database for configuration and application data and is to have same look and feel at user interface regardless of whether configuration is being done online or offline. Additional features and characteristics are as follows:
- 2.10.1.1 tool is to include:
- (1) basic system navigation tree for connected networks;
 - (2) integration of system enabled devices;
 - (3) customized user navigation tress;
 - (4) point naming operator parameter setting;
 - (5) graphic diagram configuration;
 - (6) alarm and event message routing;
 - (7) graphical logic connector tool for custom programming;
 - (8) downloading, uploading, and archiving databases.
- 2.10.1.2 tool is to have capability to automatically discover field devices on connected buses and networks;
- 2.10.1.3 tool is to be capable of configuring from a library of standard applications, simulating to verify applications, and commissioning field equipment controllers and field devices;
- 2.10.1.4 tool is to be complete with a Bluetooth Wireless Technology wireless access point to enable a wireless enabled portable computer to make a temporary Ethernet connection to automation network.
- 2.10.2 Bluetooth Wireless Technology converter is to provide temporary wireless connection between sensor-actuator bus or field-controller bus and a wireless enabled portable computer. Converter is to be powered through a connection to either sensor-actuator bus or the field-controller bus and is to support downloading and troubleshooting field equipment controllers and field devices from portable computer over wireless connection. Converter is to be complete with LED indicators for following conditions:
- 2.10.2.1 Power: On/Off;
 - 2.10.2.2 Fault: Fault/No Fault;
 - 2.10.2.3 SA/FC Bus: Bus Activity/No Bus Activity;
 - 2.10.2.4 Bluetooth: Bluetooth Communication Established/Bluetooth Communication Not Established.
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2.11 WIRING MATERIALS

- 2.11.1 System wiring, conduit, boxes, and similar materials are to be in accordance with requirements specified in Division 26 – Electrical.

3 EXECUTION

3.1 GENERAL RE: INSTALLATION OF THE BAS

- 3.1.1 Provide a complete building automation system in accordance with requirements of this Section of the Specification, Section 25 05 01 – Automatic Control Systems, drawings, and the input/output points list(s).
- 3.1.2 Unless otherwise specified, perform BAS work in accordance with system manufacturer's instructions.

3.2 INSTALLATION OF DIRECT DIGITAL CONTROL SYSTEM COMPONENTS

- 3.2.1 Provide required direct digital control hardware, software, accessories, and wiring for a complete BAS. Refer to drawing control diagrams and sequences, points list(s), and Section 25 05 01 – Automatic Control Systems.
- 3.2.2 Provide operator workstation, including required power and data connections, in a location as directed by the Owner or as indicated on drawings.
- 3.2.3 DDC work is to be performed by skilled technicians, properly trained and are qualified for this work.
- 3.2.4 Materials and equipment used are to be standard components, regularly manufactured for this and/or other systems, and not custom designed especially for this project. Systems and components are to have been thoroughly tested and proven in actual use.
- 3.2.5 System is to be modular, permitting expansion by adding hardware and software without changes in communication or processing equipment.
- 3.2.6 Provide new communications bus as required complete with required ancillaries. Connect and extend existing communications bus.
- 3.2.7 Provide 1 supervisory controller (SC) per cabinet fan (air handler). Provide necessary field equipment controllers (FEC).
- 3.2.8 Provide necessary quantity of SC to accomplish requirements of this specification, and to minimize number of mechanical systems that would be inoperative in event of a FEC failure. A maximum of 2 major mechanical systems are to be controlled by 1 FEC.
- 3.2.9 Surface wall mount SC and FEC control units in Mechanical Rooms ensuring they are not mounted on vibrating surfaces, and connect to 15A-1P circuit breakers dedicated for control system applications, in branch panel circuit boards in adjacent spaces. Power wiring from control units to circuit breakers is to be the responsibility of the controls contractor. Wiring is to be in conduit and conduit and wiring are to be in accordance with standards and requirements of Division 26 – Electrical. Refer to electrical drawings for locations of branch circuit panelboards with dedicated circuits for controls system applications.
- 3.2.10 Indicate via number, and systems controlled by SC and FEC. Indicate via a lamacoid label mounted inside panel the identification number of electrical panel supplying power to SC and FEC.
- 3.2.11 Submit schedule(s) of input/output points to Consultant for review. Directly connect each SC and FEC to point devices in accordance with control diagrams and schedule of miscellaneous control points as shown on drawings. Sensor wires for each analogue input are to be 18 AWG twisted-shielded cable. Other types of wire required are to be as recommended by system supplier.
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- 3.2.12 Provide required sensors, remote devices, etc., and required interface accessories. Mount duct and/or plenum sensors half-way across duct or plenum.
- 3.2.13 Differential pressure sensor used to provide space pressurization control through regulation of return air quantities must be mounted with snubbers on indoor pressure leg to prevent sudden fluctuations caused by door openings, etc. Mount outdoor air ports in locations that minimize effects of abnormal surface flow conditions and wind gusts.
- 3.2.14 Supply and turn over to the Consultant prior to application for a Certificate of Substantial Performance of the Work, reports to be used in assisting Owner in defining and debugging DDC programs. These reports are to consist, as a minimum, of following:
 - 3.2.14.1 process control language (PCL) logs;
 - 3.2.14.2 control loop logs;
 - 3.2.14.3 PCL master point.
- 3.2.15 Submit Point Data Input forms to the Consultant that the Owner will fill out with DDC system supplier's assistance. Input this point data into the system.
- 3.2.16 Contacts will be supplied as part of mechanical work or electrical work for alarm and status points for systems and equipment other than building environmental systems and equipment. Connect to DDC system in accordance with point schedule.

3.3 IMPLEMENTATION OF ENERGY MANAGEMENT PROGRAMS

- 3.3.1 Implement energy management programs indicated for building equipment and systems.
- 3.3.2 Ensure energy management program adjustable parameters are accessible to and adjustable by building operations personnel at operator's workstation.
- 3.3.3 Configure energy management programs so they may be enabled/disabled on an individual basis for each system to which they apply.

3.4 CONTROL WIRING

- 3.4.1 Perform required control wiring work for control systems except:
 - 3.4.1.1 power wiring connections to equipment and panels, except as noted below;
 - 3.4.1.2 control wiring associated with mechanical plant equipment and systems whose control is not part of work specified in this Section;
 - 3.4.1.3 starter interlock wiring.
- 3.4.2 Except as specified below, install wiring in conduit. Unless otherwise specified, final 600 mm (2') connections to sensors and transmitters, and wherever conduit extends across flexible duct connections is to be liquid-tight flexible conduit.
- 3.4.3 Control wiring in ceiling spaces and wall cavities may be plenum rated cable installed without conduit but neatly harnessed, secured, and identified.
- 3.4.4 Wiring work is to be in accordance with BAS manufacturer's certified wiring schematics and instructions, and wiring standards specified in electrical work Division of this Specification.

3.5 IDENTIFICATION AND LABELLING OF EQUIPMENT AND CIRCUITS

- 3.5.1 Refer to Section 20 05 00 – Common Work Results for Mechanical.
 - 3.5.2 Identify BAS equipment as follows:
 - 3.5.2.1 enclosures: engraved laminated nameplates with lettering such as BAS Panel CP2, or BAS Relays, or BAS E/P Transformers, with all wording listed and approved prior to manufacture of nameplates;
 - 3.5.2.2 panel points: a weather-proof input/output layout sheet for each controller with the name of each point connected to controller, and associated wire labelling information;
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- 3.5.2.3 wiring: numbered sleeves or plastic rings at both ends of conductor, with numbering corresponding to conductor identification on shop drawings and "as-built" record drawings;
- 3.5.2.4 interface components: a weather-proof layout sheet clearly illustrating/identifying purpose of each component within enclosure such that an operator or service technician can quickly identify exact use of each relay, transducer, contactor, etc., with each sheet fastened securely to back of enclosure door.

3.6 SYSTEM STARTUP

- 3.6.1 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.
- 3.6.2 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.7 CLOSEOUT ACTIVITIES

- 3.7.1 Include for demonstration and training sessions for each of 2 groups of Owner's operating and maintenance personnel as follows:
 - 3.7.1.1 3 full, 8 hour day orientation sessions at system manufacturer's office to educate personnel on BAS architecture, hardware, and software, with an overview of BAS operation and capabilities including but not limited to operational programmes, equipment functions (both individually and as part of a total integrated system), BAS commands, advisories, alarms, and appropriate operator intervention required in responding to BAS operation;
 - 3.7.1.2 2 full, 8 hour day sessions at site using BAS for a "hands-on" demonstration of BAS functions and features with instruction regarding chronological flow of information from field devices, contacts and sensors to operator's workstation, an overview of communications network describing interplay between initiating devices, field hardware panels, systems communications, and their importance within operating BAS, and alarm indications and appropriate responses;
 - 3.7.1.3 2 full, 8 hour day seasonal (summer-winter) site sessions to perform additional instruction regarding seasonal changes and how they affect BAS.
- 3.7.2 Include for 2 follow-up site training and troubleshooting visits, one 6 months after Substantial Completion and other at end of warranty period, both when arranged by Owner and for a full day to provide additional system training as required.

END OF SECTION

SECTION 25 06 00 - INTEGRATED AUTOMATION POINTS SCHEDULE
LIST CITY OF MISSISSAUGA FIRE STATION 123
3050 THE COLLEGEWAY, MISSISSAUGA, ONTARIO, CANADA

System Identifier	Location	Power Panel	Sequence	Serving	
Air Circulator Fan	Apparatus Bay			Apparatus Bay	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	APCF1_CMD	Apparatus Bay Air Circulator Fan 1 Command	Do	On/Off	
New Points	APCF2_CMD	Apparatus Bay Air Circulator Fan 2 Command	Do	On/Off	
New Points	APCF3_CMD	Apparatus Bay Air Circulator Fan 3 Command	Do	On/Off	
New Points	APCF4_CMD	Apparatus Bay Air Circulator Fan 4 Command	Do	On/Off	
New Points	APCF1_STS	Apparatus Bay Air Circulator Fan 1 Status	Di	On/Off	
New Points	APCF1_STS	Apparatus Bay Air Circulator Fan 2 Status	Di	On/Off	
New Points	APCF1_STS	Apparatus Bay Air Circulator Fan 3 Status	Di	On/Off	
New Points	APCF1_STS	Apparatus Bay Air Circulator Fan 4 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Air Circulator Fan	Apparatus Bay			Bunker Gear & Hose Room	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	BGRWF1_CMD	Bunker Room Air Circulator Fan 1 Command	Do	On/Off	
New Points	BGRWF2_CMD	Bunker Room Air Circulator Fan 2 Command	Do	On/Off	
New Points	HRCW3_CMD	Hose Room Air Circulator Fan 2 Command	Do	On/Off	
New Points	BGRWF1_STS	Bunker Room Air Circulator Fan 1 Status	Di	On/Off	
New Points	BGRWF2_STS	Bunker Room Air Circulator Fan 2 Status	Di	On/Off	
New Points	HRCW3_STS	Hose Room Air Circulator Fan 3 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Vehicle Exhaust Fan	Apparatus Bay			Vehicle Exhaust Tail Pipe	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	APEF1_CMD	Apparatus Bay Vehicle Exhaust Fan 1 Command	Do	On/Off	
New Points	APEF1_STS	Apparatus Bay Vehicle Exhaust Fan 1 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Exhaust Fan	Apparatus Bay			Apparatus Bay	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	APEF2_CMD	Apparatus Bay Exhaust Fan 2 Command	Do	On/Off	
New Points	APEF2_STS	Apparatus Bay Exhaust Fan 2 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Exhaust Fan	Rooftop			Workshop Room	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	WSREF3_CMD	Workshop Room Exhaust Fan 3 Command	Do	On/Off	
New Points	WSREF3_STS	Workshop Room Exhaust Fan 3 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Exhaust Fan	Rooftop			Bunker Room	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	WSREF4_CMD	Workshop Room Exhaust Fan 4 Command	Do	On/Off	
New Points	WSREF4_STS	Workshop Room Exhaust Fan 4 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Exhaust Fan	Kitchen Range Hood			Kitchen	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	RH1_CMD	Kitchen Range Hood Exhaust Fan 1 Command	Do	On/Off	
New Points	RH1_STS	Kitchen Range Hood Exhaust Fan 1 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Exhaust Fan	Kitchen Range Hood			Kitchen	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Points	RH1_CMD	Kitchen Range Hood Exhaust Fan 1 Command	Do	On/Off	
New Points	RH1_STS	Kitchen Range Hood Exhaust Fan 1 Status	Di	On/Off	
System Identifier	Location	Power Panel	Sequence	Serving	
Split Air Conditioning	Rooftop & IT Room			IT Room	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments

SECTION 25 06 00 - INTEGRATED AUTOMATION POINTS SCHEDULE
LIST CITY OF MISSISSAUGA FIRE STATION 123
3050 THE COLLEGEWAY, MISSISSAUGA, ONTARIO, CANADA

System Identifier	Location	Power Panel	Sequence	Serving	
New Point	CND1BACNET_COM	Condenser 1 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC13BACNET_COM	Fan Coil 13 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	CND1_CMD	Condenser 1 Command	Do	On/Off	
New Point	FC13_CMD	Fan Coil 13 Command	Do	On/Off	
New Point	CND1_STS	Condenser 1 Status	Di	On/Off	
New Point	FC13_STS	Fan Coil 13 Status	Di	On/Off	
New Point	FC13MODE_CMD	Fan Coil 13 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC13SAT_T	Fan Coil 13 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC13RAT_T	Fan Coil 13 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC13SAT_SPT_WINT	Fan Coil 13 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC13SAT_SPT_SUMM	Fan Coil 13 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC13SAT_SPT_CLG	Fan Coil 13 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC13ITRM_SPT	Fan Coil 13 Space Setpoint	VP	°C	Virtual Point
New Point	FC13ITRMT123_T	Fan Coil 13 IT Room Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 123
System Identifier	Location	Power Panel	Sequence	Serving	
Split Air Conditioning	Rooftop & Electrical Room			Electrical Room	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Point	CND2BACNET_COM	Condenser 2 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC14BACNET_COM	Fan Coil 14 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	CND2_CMD	Condenser 2 Command	Do	On/Off	
New Point	FC14_CMD	Fan Coil 14 Command	Do	On/Off	
New Point	CND2_STS	Condenser 2 Status	Di	On/Off	
New Point	FC14_STS	Fan Coil 14 Status	Di	On/Off	
New Point	FC14MODE_CMD	Fan Coil 14 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC14SAT_T	Fan Coil 14 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC14RAT_T	Fan Coil 14 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC14SAT_SPT_WINT	Fan Coil 14 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC14SAT_SPT_SUMM	Fan Coil 14 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC14SAT_SPT_CLG	Fan Coil 14 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC14ITRM_SPT	Fan Coil 14 Space Setpoint	VP	°C	Virtual Point
New Point	FC14ITRMT135_T	Fan Coil 14 Electrical Room Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 135
System Identifier	Location	Power Panel	Sequence	Serving	
VRF	Rooftop & Various Rooms			Various Rooms	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Point	HP1BACNET_COM	Heat Pump 1 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC1BACNET_COM	Fan Coil 1 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC2BACNET_COM	Fan Coil 2 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC3BACNET_COM	Fan Coil 3 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC4BACNET_COM	Fan Coil 4 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC5BACNET_COM	Fan Coil 5 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC6BACNET_COM	Fan Coil 6 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC12BACNET_COM	Fan Coil 12 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	HP1_CMD	Heat Pump 1 Command	Do	On/Off	
New Point	FC1_CMD	Fan Coil 1 Command	Do	On/Off	
New Point	FC2_CMD	Fan Coil 2 Command	Do	On/Off	
New Point	FC3_CMD	Fan Coil 3 Command	Do	On/Off	
New Point	FC4_CMD	Fan Coil 4 Command	Do	On/Off	
New Point	FC5_CMD	Fan Coil 5 Command	Do	On/Off	
New Point	FC6_CMD	Fan Coil 6 Command	Do	On/Off	
New Point	FC12_CMD	Fan Coil 12 Command	Do	On/Off	
New Point	HP1_STS	Heat Pump 1 Status	Di	On/Off	
New Point	FC1_STS	Fan Coil 1 Status	Di	On/Off	
New Point	FC2_STS	Fan Coil 2 Status	Di	On/Off	
New Point	FC3_STS	Fan Coil 3 Status	Di	On/Off	
New Point	FC4_STS	Fan Coil 4 Status	Di	On/Off	
New Point	FC5_STS	Fan Coil 5 Status	Di	On/Off	
New Point	FC6_STS	Fan Coil 6 Status	Di	On/Off	
New Point	FC12_STS	Fan Coil 12 Status	Di	On/Off	

SECTION 25 06 00 - INTEGRATED AUTOMATION POINTS SCHEDULE
LIST CITY OF MISSISSAUGA FIRE STATION 123
3050 THE COLLEGEWAY, MISSISSAUGA, ONTARIO, CANADA

System Identifier	Location	Power Panel	Sequence	Serving	
New Point	FC1MODE_CMD	Fan Coil 1 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC2MODE_CMD	Fan Coil 2 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC3MODE_CMD	Fan Coil 3 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC4MODE_CMD	Fan Coil 4 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC5MODE_CMD	Fan Coil 5 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC6MODE_CMD	Fan Coil 6 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC12MODE_CMD	Fan Coil 12 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC1SAT_T	Fan Coil 1 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC2SAT_T	Fan Coil 2 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC3SAT_T	Fan Coil 3 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC4SAT_T	Fan Coil 4 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC5SAT_T	Fan Coil 5 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC6SAT_T	Fan Coil 6 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC12SAT_T	Fan Coil 12 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC1RAT_T	Fan Coil 1 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC2RAT_T	Fan Coil 2 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC3RAT_T	Fan Coil 3 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC4RAT_T	Fan Coil 4 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC5RAT_T	Fan Coil 5 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC6RAT_T	Fan Coil 6 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC12RAT_T	Fan Coil 12 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC1SAT_SPT_WINT	Fan Coil 1 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC2SAT_SPT_WINT	Fan Coil 2 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC3SAT_SPT_WINT	Fan Coil 3 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC4SAT_SPT_WINT	Fan Coil 4 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC5SAT_SPT_WINT	Fan Coil 5 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC6SAT_SPT_WINT	Fan Coil 6 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC12SAT_SPT_WINT	Fan Coil 12 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC1SAT_SPT_SUMM	Fan Coil 1 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC2SAT_SPT_SUMM	Fan Coil 2 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC3SAT_SPT_SUMM	Fan Coil 3 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC4SAT_SPT_SUMM	Fan Coil 4 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC5SAT_SPT_SUMM	Fan Coil 5 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC6SAT_SPT_SUMM	Fan Coil 6 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC12SAT_SPT_SUMM	Fan Coil 12 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC1SAT_SPT_CLG	Fan Coil 1 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC2SAT_SPT_CLG	Fan Coil 2 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC3SAT_SPT_CLG	Fan Coil 3 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC4SAT_SPT_CLG	Fan Coil 4 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC5SAT_SPT_CLG	Fan Coil 5 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC6SAT_SPT_CLG	Fan Coil 6 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC12SAT_SPT_CLG	Fan Coil 12 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC1COT103_SPT	Fan Coil 1 Space Setpoint	VP	°C	Virtual Point
New Point	FC2DCT102_SPT	Fan Coil 2 Space Setpoint	VP	°C	Virtual Point
New Point	FC3GYMT107_SPT	Fan Coil 3 Space Setpoint	VP	°C	Virtual Point
New Point	FC4DORMT113_SPT	Fan Coil 4 Space Setpoint	VP	°C	Virtual Point
New Point	FC5LRMT119_SPT	Fan Coil 5 Space Setpoint	VP	°C	Virtual Point
New Point	FC6CORT_SPT	Fan Coil 6 Space Setpoint	VP	°C	Virtual Point
New Point	FC12TRM_SPT	Fan Coil 12 Space Setpoint	VP	°C	Virtual Point
New Point	FC1COT103_T	Fan Coil 1 Captain Office Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 103
New Point	FC2DCT102_T	Fan Coil 2 District Chief Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 102
New Point	FC3GYMT107_T	Fan Coil 3 Gym Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 107
New Point	FC4DORMT113_T	Fan Coil 4 Dorm Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 113
New Point	FC5LRMT119_T	Fan Coil 5 Locker Room Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 119
New Point	FC6CORT_T	Fan Coil 6 Corridor Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Corridor
New Point	FC12COT104_T	Fan Coil 12 Captain Office Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 104
System Identifier	Location	Power Panel	Sequence	Serving	
VRF	Rooftop & Various Rooms			Various Rooms	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments

System Identifier	Location	Power Panel	Sequence	Serving	
New Point	HP2BACNET_COM	Heat Pump 2 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC8BACNET_COM	Fan Coil 8 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC9BACNET_COM	Fan Coil 9 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC10BACNET_COM	Fan Coil 10 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	FC11BACNET_COM	Fan Coil 11 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	HP2_CMD	Heat Pump 2 Command	Do	On/Off	
New Point	FC8_CMD	Fan Coil 8 Command	Do	On/Off	
New Point	FC9_CMD	Fan Coil 9 Command	Do	On/Off	
New Point	FC10_CMD	Fan Coil 10 Command	Do	On/Off	
New Point	FC11_CMD	Fan Coil 11 Command	Do	On/Off	
New Point	HP2_STS	Heat Pump 2 Status	Di	On/Off	
New Point	FC8_STS	Fan Coil 8 Status	Di	On/Off	
New Point	FC9_STS	Fan Coil 9 Status	Di	On/Off	
New Point	FC10_STS	Fan Coil 10 Status	Di	On/Off	
New Point	FC11_STS	Fan Coil 11 Status	Di	On/Off	
New Point	FC8MODE_CMD	Fan Coil 8 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC9MODE_CMD	Fan Coil 9 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC10MODE_CMD	Fan Coil 10 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC11MODE_CMD	Fan Coil 11 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet
New Point	FC8SAT_T	Fan Coil 8 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC9SAT_T	Fan Coil 9 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC10SAT_T	Fan Coil 10 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC11SAT_T	Fan Coil 11 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	FC8RAT_T	Fan Coil 8 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC9RAT_T	Fan Coil 9 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC10RAT_T	Fan Coil 10 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC11RAT_T	Fan Coil 11 Return Air Temperature	VP	°C	Point read via BACNet
New Point	FC8SAT_SPT_WINT	Fan Coil 8 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC9SAT_SPT_WINT	Fan Coil 9 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC10SAT_SPT_WINT	Fan Coil 10 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC11SAT_SPT_WINT	Fan Coil 11 Winter Supply Air Setpoint	VP	°C	Virtual Point
New Point	FC8SAT_SPT_SUMM	Fan Coil 8 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC9SAT_SPT_SUMM	Fan Coil 9 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC10SAT_SPT_SUMM	Fan Coil 10 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC11SAT_SPT_SUMM	Fan Coil 11 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC8SAT_SPT_CLG	Fan Coil 8 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC9SAT_SPT_CLG	Fan Coil 9 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC10SAT_SPT_CLG	Fan Coil 10 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC11SAT_SPT_CLG	Fan Coil 11 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled
New Point	FC8DAT127_SPT	Fan Coil 8 Space Setpoint	VP	°C	Virtual Point
New Point	FC9DLT144_SPT	Fan Coil 9 Space Setpoint	VP	°C	Virtual Point
New Point	FC10BGRM138_SPT	Fan Coil 10 Space Setpoint	VP	°C	Virtual Point
New Point	FC11ITRM_SPT	Fan Coil 11 Space Setpoint	VP	°C	Virtual Point
New Point	FC8DAT127_T	Fan Coil 8 Dining Area Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 127
New Point	FC9DLT144_T	Fan Coil 9 Dayroom Lounge Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 144
New Point	FC10BGRM138_T	Fan Coil 10 Bunker Gear Room Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room138
New Point	FC11LAUNT137_T	Fan Coil 11 Laundry Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 137
System Identifier	Location	Power Panel	Sequence	Serving	
UNIT HEATER	Various Area			Various Area	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Point	UH1BACNET_COM	Unit Heater 1 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH2BACNET_COM	Unit Heater 2 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH3BACNET_COM	Unit Heater 3 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH4BACNET_COM	Unit Heater 4 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH5BACNET_COM	Unit Heater 5 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH6BACNET_COM	Unit Heater 6 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH7BACNET_COM	Unit Heater 7 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH8BACNET_COM	Unit Heater 8 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	UH9BACNET_COM	Unit Heater 9 BacNet Communication (MS/TP)	COM	Online/Offline	

SECTION 25 06 00 - INTEGRATED AUTOMATION POINTS SCHEDULE
LIST CITY OF MISSISSAUGA FIRE STATION 123
3050 THE COLLEGEWAY, MISSISSAUGA, ONTARIO, CANADA

System Identifier	Location	Power Panel	Sequence	Serving	
New Point	UH1_CMD	Unit Heater 1 Command	Do	On/Off	
New Point	UH2_CMD	Unit Heater 2 Command	Do	On/Off	
New Point	UH3_CMD	Unit Heater 3 Command	Do	On/Off	
New Point	UH4_CMD	Unit Heater 4 Command	Do	On/Off	
New Point	UH5_CMD	Unit Heater 5 Command	Do	On/Off	
New Point	UH6_CMD	Unit Heater 6 Command	Do	On/Off	
New Point	UH7_CMD	Unit Heater 7 Command	Do	On/Off	
New Point	UH8_CMD	Unit Heater 8 Command	Do	On/Off	
New Point	UH9_CMD	Unit Heater 9 Command	Do	On/Off	
New Point	UH1_STS	Unit Heater 1 Status	Di	On/Off	
New Point	UH2_STS	Unit Heater 2 Status	Di	On/Off	
New Point	UH3_STS	Unit Heater 3 Status	Di	On/Off	
New Point	UH4_STS	Unit Heater 4 Status	Di	On/Off	
New Point	UH5_STS	Unit Heater 5 Status	Di	On/Off	
New Point	UH6_STS	Unit Heater 6 Status	Di	On/Off	
New Point	UH7_STS	Unit Heater 7 Status	Di	On/Off	
New Point	UH8_STS	Unit Heater 8 Status	Di	On/Off	
New Point	UH9_STS	Unit Heater 9 Status	Di	On/Off	
New Point	UH1MODE_CMD	Unit Heater 1 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH2MODE_CMD	Unit Heater 2 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH3MODE_CMD	Unit Heater 3 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH4MODE_CMD	Unit Heater 4 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH5MODE_CMD	Unit Heater 5 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH6MODE_CMD	Unit Heater 6 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH7MODE_CMD	Unit Heater 7 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH8MODE_CMD	Unit Heater 8 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH9MODE_CMD	Unit Heater 9 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	UH1SAT_T	Unit Heater 1 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH2SAT_T	Unit Heater 2 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH3SAT_T	Unit Heater 3 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH4SAT_T	Unit Heater 4 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH5SAT_T	Unit Heater 5 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH6SAT_T	Unit Heater 6 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH7SAT_T	Unit Heater 7 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH8SAT_T	Unit Heater 8 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH9SAT_T	Unit Heater 9 Supply Air Temperature	VP	°C	Point read via BACNet
New Point	UH1VES100_SPT	Unit Heater 1 Space Setpoint	VP	°C	Virtual Point
New Point	UH2SP134_SPT	Unit Heater 2 Space Setpoint	VP	°C	Virtual Point
New Point	UH3VES112_SPT	Unit Heater 3 Space Setpoint	VP	°C	Virtual Point
New Point	UH4DL128_SPT	Unit Heater 4 Space Setpoint	VP	°C	Virtual Point
New Point	UH5OS141_SPT	Unit Heater 5 Space Setpoint	VP	°C	Virtual Point
New Point	UH6APB130_SPT	Unit Heater 6 Space Setpoint	VP	°C	Virtual Point
New Point	UH7APB130_SPT	Unit Heater 7 Space Setpoint	VP	°C	Virtual Point
New Point	UH8APB130_SPT	Unit Heater 8 Space Setpoint	VP	°C	Virtual Point
New Point	UH9APB130_SPT	Unit Heater 9 Space Setpoint	VP	°C	Virtual Point
New Point	UH1VES100_T	Unit Heater 1 Vestibule Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Vestibule 100
New Point	UH2SP134_T	Unit Heater 2 Sprinkler Room Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Sprinkler Room 134
New Point	UH3VES112_T	Unit Heater 3 Vestibule Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Vestibule 112
New Point	UH4DL128_T	Unit Heater 4 Dayroom Lounge Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Dayroom Lounge 128
New Point	UH5OS141_T	Unit Heater 5 Outdoor Storage Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Outdoor Storage 141
New Point	UH6APB130_T	Unit Heater 6 Apparatus Bay Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Apparatus Bay 130
New Point	UH7APB130_T	Unit Heater 7 Apparatus Bay Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Apparatus Bay 130
New Point	UH8APB130_T	Unit Heater 8 Apparatus Bay Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Apparatus Bay 130
New Point	UH9APB130_T	Unit Heater 9 Apparatus Bay Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Apparatus Bay 130
System Identifier	Location	Power Panel	Sequence	Serving	
In floor Heating	Mechanical Room/Apparatus Bay			Apparatus Bay	
Existing Point Name	Tag	Point Description	Type	Units in Display	Comments
New Point	C1BACNET_COM	Boiler 1 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	RFH1BACNET_COM	Radiant Floor Heating 1 BacNet Communication (MS/TP)	COM	Online/Offline	

System Identifier	Location	Power Panel	Sequence	Serving	
New Point	RFH2BACNET_COM	Radiant Floor Heating 2 BacNet Communication (MS/TP)	COM	Online/Offline	
New Point	B1_CMD	Boiler 1 Command	Do	On/Off	
New Point	RFH1_CMD	Radiant Floor Heating 1 Command	Do	On/Off	
New Point	RFH2_CMD	Radiant Floor Heating 2 Command	Do	On/Off	
New Point	B1_STS	Boiler 1 Status	Di	On/Off	
New Point	RFH1_STS	Radiant Floor Heating 1 Status	Di	On/Off	
New Point	RFH2_STS	Radiant Floor Heating 2 Status	Di	On/Off	
New Point	B1MODE_CMD	Boiler 1 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	RFH1MODE_CMD	Radiant Floor Heating 1 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	RFH2MODE_CMD	Radiant Floor Heating 2 Control Mode	VP	Unoccupied	Control point via BACNet
New Point	B1SAT_T	Boiler 1 Supply Water Temperature	VP	°C	Point read via BACNet
New Point	B1RAT_T	Boiler 1 Return Water Temperature	VP	°C	Point read via BACNet
New Point	RFH1APB130_SPT	Radiant Floor Heating 1 Space Setpoint	VP	°C	Virtual Point
New Point	RFH2APB130_SPT	Radiant Floor Heating 2 Space Setpoint	VP	°C	Virtual Point
New Point	RFH1APB130_T	Radiant Floor Heating 1 Space Temperature	AI	°C	New Flat Plate Sensor Installed in Apparatus Bay 130
New Point	RFH2APB130_T	Radiant Floor Heating 2 Space Temperature	AI	°C	New Flat Plate Sensor Installed in Apparatus Bay 130

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 The purpose of this section is to specify Division 25 responsibilities in the commissioning process.
- 1.1.2 Commissioning requires the participation of Division 25 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 13. Division 25 shall be familiar with all parts of Section 01 91 13 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 REFERENCES

- 1.2.1 2023 ASHRAE Handbook – HVAC Applications, Chapter 43 HVAC Commissioning.
- 1.2.2 ASHRAE Guideline 1.1–2007, HVAC&R Technical Requirements for the Commissioning Process.
- 1.2.3 ASHRAE Guideline 0–2019, The Commissioning Process.
- 1.2.4 ASHRAE Guideline 4-2008 – Preparation of O&M Documentation.
- 1.2.5 ASHRAE/IES Standard 202–2018 – Commissioning Process for Buildings and Systems.
- 1.2.6 CSA Z320-11 (R2021), Building Commissioning Standard & Check Sheets.
- 1.2.7 CSA C282:19, Emergency power supply for buildings.
- 1.2.8 CAN/ULC-S1001-11, Integrated Systems Testing of Fire Protection and Life Safety Systems and Fire Protection Commissioning.

1.3 SUBMITTALS

- 1.3.1 Division 25 Contractors shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 01 91 13, Article “Submittals” for additional Division 25 requirements.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Written work products of Division 25 Contractors will consist of the startup and initial checkout plan as described in Section 01 91 13, as well as completed startup, initial checkout, and pre-functional test sheets.

1.5 OPERATIONS AND MAINTENANCE DATA

- 1.5.1 Division 25 Contractors shall compile and prepare documentation for all equipment and systems covered in Division 25 and deliver to the GC for inclusion in the O&M manuals.
- 1.5.2 ASHRAE Guideline 4-2008 is the recommended format.
- 1.5.3 The CxA shall receive a copy of the O&M manuals for review.

1.6 SYSTEMS TO BE COMMISSIONED

- 1.6.1 The following systems shall be commissioned as part of this contract:
 - 1.6.1.1 Building Automation System (BAS).

1.7 COMMISSIONING TEAM

- 1.7.1 The Commissioning Team shall consist of representatives of the following:
 - 1.7.1.1 Owner and the Owner's Operating and Maintenance Staff.
 - 1.7.1.2 Architect.
 - 1.7.1.3 Mechanical Design Engineer.
-

- 1.7.1.4 Commissioning Agent (CxA).
- 1.7.1.5 General Contractor.
- 1.7.1.6 Mechanical Contractor.
- 1.7.1.7 Controls Sub-Contractor.
- 1.7.1.8 Electrical Sub-Contractor.
- 1.7.1.9 Testing, Adjusting, and Balancing Agency.

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 COMMISSIONING AGENT'S RESPONSIBILITIES

- 3.1.1 The Commissioning Agent shall:
 - 3.1.1.1 Plan, organize and implement the commissioning process as specified herein.
 - 3.1.1.2 Prepare the commissioning plan, ensure its distribution for review and comment.
 - 3.1.1.3 Revise the commissioning plan as required during construction.
 - 3.1.1.4 Chair commissioning meetings. Prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting.
 - 3.1.1.5 In conjunction with the GC and trades, coordinate commissioning activities.
 - 3.1.1.6 Monitor system verification checks, and ensure the results are documented as the checks are done.
 - 3.1.1.7 Monitor controls point-to-point checks done by controls, and ensure the results documented as the checks are done.
 - 3.1.1.8 Observe select start-ups and initial system operations tests and checks.
 - 3.1.1.9 Direct GC and trades to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes.
 - 3.1.1.10 Witness functional performance tests and document the results.
 - 3.1.1.11 Prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each.
 - 3.1.1.12 Ensure all required O&M manuals, instructions and demonstrations are provided to the Owner's designated operating staff.

3.2 ENGINEER OF RECORD RESPONSIBILITIES

- 3.2.1 Engineer of Record commissioning responsibilities are outlined below:
 - 3.2.1.1 Review the commissioning plan, and participate, as appropriate, in on-site commissioning meetings.
 - 3.2.1.2 At their discretion during the acceptance phase of the commissioning process, be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- 3.3.1 The Owner shall have the following commissioning responsibilities.
 - 3.3.1.1 Ensure the availability of operating staff for all scheduled instruction and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.

3.4 CONTROLS CONTRACTOR RESPONSIBILITIES

- 3.4.1 The responsibilities of the Controls contractor, during construction and acceptance phases in addition to those listed above are as follows:
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- 3.4.1.1 Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
- (1) An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components, and function.
 - (2) All interactions and interlocks with other systems.
 - (3) Detailed delineation of control between any packaged controls and the BAS, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
 - (4) Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included but will generally require additional narrative).
 - (5) Start-up sequences.
 - (6) Warm-up mode sequences.
 - (7) Normal operating mode sequences.
 - (8) Unoccupied mode sequences.
 - (9) Shutdown sequences.
 - (10) Capacity control sequences and equipment staging.
 - (11) Temperature and pressure control: setbacks, setups, resets, etc.
 - (12) Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
 - (13) Effects of power or equipment failure with all standby component functions.
 - (14) Sequences for all alarms and emergency shutdowns.
 - (15) Seasonal operational differences and recommendations.
 - (16) Initial setpoints and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
 - (17) Schedules, if known.
 - (18) To facilitate referencing in testing procedures, all sequences shall be written in concise statements.
- 3.4.1.2 Control Drawings Submittal
- (1) The control drawings shall have a key to all abbreviations.
 - (2) The control drawings shall contain graphic schematic depictions of the systems and each component (i.e., sensors, dampers, coils, valves, etc.)
 - (3) The schematics will include the system and component layout of any equipment that the control system monitors, enables, or controls, even if the equipment is primarily controlled by packaged or integral controls.
 - (4) Provide a full points list with at least the following included for each point:
 - (A) Controlled system
-

- (B) Point abbreviation
- (C) Point description
- (D) Display unit
- (E) Control point or setpoint (Yes / No)
- (F) Monitoring point (Yes / No)
- (G) Intermediate point (Yes / No)
- (H) Calculated point (Yes / No)
- (I) Key:
 - (a) Point Description: DB temp, air flow, etc.
 - (b) Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)
 - (c) Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
 - (d) Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
 - (e) Calculated Point: "Virtual" point generated from calculations of other point values.

- 3.4.1.3 The Controls Contractor shall keep the CxA informed of all changes to this list during programming and setup.
 - 3.4.1.4 As-Built Controls Package - An updated as-built version of the Controls Drawings and Sequence of Operation, which is to include all items identified above, shall be provided to the CxA and included in the final controls O&M manual submittal.
 - 3.4.1.5 Assist in TAB Work- The Controls Contractor shall assist in the TAB work through the following:
 - (1) Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB Contractor any needed unique instruments for setting terminal unit boxes and instruct the TAB Contractor in their use (handheld control system interface for use around the building during TAB, etc.).
 - (2) For a given area, have all required pre-functional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CxA prior to TAB.
 - (3) Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB or provide sufficient training for TAB to operate the system without assistance.
 - 3.4.1.6 Required assistance to the CxA - Assist and cooperate with the CxA in the following manner:
 - (1) Using a skilled technician who is familiar with the building, execute the functional testing of all equipment specified in Section 01 91 13 under direction of the CxA. Provide two-way radios during the testing.
 - (2) Execute all control system trend logs specified in Section 01 91 13.
-

- (3) Written Plan - The Controls Contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, according to the process in Section 01 91 13. At minimum, the plan shall include the following for each type of equipment controlled by the automatic controls:
 - (A) System name.
 - (B) List of devices.
 - (C) Step-by-step procedures for testing each controller after installation, including:
 - (a) Process of verifying proper hardware and wiring installation.
 - (b) Process of downloading programs to local controllers and verifying that they are addressed correctly.
 - (c) Process of performing operational checks of each controlled component.
 - (d) Plan and process for calibrating valve and damper actuators and all sensors.
 - (e) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
 - (4) A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has "passed" and is operating within the contract parameters.
 - (5) A description of the instrumentation required for testing.
 - (6) Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CxA and TAB contractor for this determination.
- 3.4.1.7 Checkout Certification - Provide a signed and dated certification report to the CxA and PM/GC upon completion of the checkout of each controlled device, equipment and system prior to functional testing. This report shall serve as confirmation that all system programming is complete in accordance to the Contract Documents, with the exception functional testing requirements. The checkout report shall also include complete point-to-point verification and sequence of operations verification checklists.
- 3.4.1.8 List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

3.5 SYSTEM STARTUP

- 3.5.1 The Controls Contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 13, Article "Start-up, Pre-Functional Test Sheets, and Initial Checkout." Division 23 has start-up responsibility and is required to complete systems and sub-systems, so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the CxA or Owner.
-

- 3.5.2 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and GC. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- 3.5.3 Prior to the start up of equipment the Division 25 Contractor shall arrange to have the Manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- 3.5.4 The Supplier shall submit a written report of their findings.
- 3.5.5 Upon confirmation that the equipment has been installed in accordance with the Manufacturers Recommendations the equipment may be started.
- 3.5.6 All equipment shall be started by the Manufacturer's representative.

3.6 PRE-FUNCTIONAL TEST SHEETS

- 3.6.1 Pre-functional test sheets contain items for Section 25 Contractors to perform. On each checklist, a column is provided that is to be completed by the contractor assigning responsibility for that line item to a trade. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- 3.6.2 Refer to Section 01 91 13 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CxA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = all Contractors, CxA = Commissioning Agent, CC = Controls Contractor, EC = Electrical Contractor, PM/GC = General Contractor, MC = Mechanical Contractor, SC = Sheet Metal Contractor, TAB = Test and Balance Contractor.

3.7 TRAINING

- 3.7.1 The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 13 for additional details.
- 3.7.2 The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01 91 13 for additional details.
- 3.7.3 Controls Contractor. The controls contractor shall have the following training responsibilities:
 - 3.7.3.1 Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 13, Article "Training".
 - 3.7.3.2 Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of the BAS system.
 - 3.7.3.3 Training shall start with classroom sessions, if necessary, followed by hands on training on the BAS, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

- 3.7.3.4 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary, and the demonstration repeated.
- 3.7.3.5 The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
- 3.7.3.6 Training shall include:
 - (1) Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - (2) Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - (3) Discuss relevant health and safety issues and concerns.
 - (4) Discuss warranties and guarantees.
 - (5) Cover common troubleshooting problems and solutions.
 - (6) Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
 - (7) Discuss any peculiarities of equipment installation or operation.
 - (8) Classroom sessions shall include the use of overhead projections, slides, video, and audio taped material as might be appropriate.
- 3.7.3.7 Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and maintenance of all pieces of equipment.
- 3.7.3.8 The Controls Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- 3.7.3.9 Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager. Training shall be videotaped.

3.8 DEFERRED TESTING

- 3.8.1 Refer to Section 01 91 13, Article "Deferred Testing" for requirements of deferred testing.

END OF SECTION

1 GENERAL

1.1 SYSTEM DESCRIPTION

- 1.1.1 Unified Lighting Control System shall consist of BACnet native lighting controllers, Centralized Panels and/or Distributed Controllers, which reside on the BACnet MS/TP network of the Building Automation System (BAS). The Unified Lighting Control System shall be an integral part of the BAS such that the operator experiences one unified system of controlling, monitoring, scheduling, trending, alarming, etc.
 - 1.1.1.1 Systems that require option card, gateway or protocol translator are not acceptable.
 - (1) BACnet MSTP/IP Routers are acceptable when detailed on the drawings.
 - 1.1.1.2 Systems that require separate master controller, server, or front-end computer are not acceptable.
 - 1.1.1.3 Systems that require client or server licensing are not acceptable.
 - 1.1.1.4 Systems that have an actuation time greater than 100 milliseconds are not acceptable. Actuation time is measured from an occupant signal (via low voltage field device; addressable stations, occupancy sensors, wall switches, etc.) to the first relay actuation. Succeeding relays may be delayed to minimize peak demand.
- 1.1.2 Unified Lighting Control System shall also consist of, as detailed on the drawings, Satellites and low voltage field devices such as; Stations, occupancy sensors, wall switches, and light level sensors.
 - 1.1.2.1 Systems utilizing pre-manufactured cables or proprietary wire to connect low voltage field devices to Centralized Panels, Distributed Controllers, or Satellites are not acceptable.
- 1.1.3 Unified Lighting Control System shall directly control the lighting as specified in this Section 3.6 – Sequence of Operations for Unified Lighting Controls.

1.2 SCOPE OF WORK

- 1.2.1 The BAS Controls Contractor shall furnish all components of the Unified Lighting Control System as detailed on the drawings and specifications. These components shall consist of Centralized Panels, Distributed Controllers, Satellites, and low voltage field devices such as Stations, occupancy sensors, wall switches, and light level sensors. The BAS Controls Contractor shall provide the Electrical Contractor all necessary documents, including approved submittal package, riser diagrams and termination schematics required to provide a complete and correct installation.
- 1.2.2 The Electrical Contractor under Division 26 shall furnish all labor to install the Unified Lighting Control System furnished by the BAS Controls Contractor. The Electrical Contractor shall receive the Unified Lighting Control System components from the BAS Controls Contractor and store them in a secure and dry location. The Electrical Contractor shall provide all of the required materials (conduit, raceways, wire, etc.) and make all of the line and low voltage wiring terminations for the furnished equipment to ensure the Unified Lighting Control System functions properly and in accordance with the specifications and drawings. The Electrical Contractor shall provide installation as-built drawings to the BAS Controls Contractor.

1.3 RELATED REQUIREMENTS

- 1.3.1 The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.
 - 1.3.2 The following sections constitute related work:
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- 1.3.2.1 Other sections of Division 25 – Integrated Automation.
- 1.3.2.2 Section 26 09 43 – Network Lighting Controls.
- 1.3.2.3 Section 26 27 26 – Wiring Devices.

1.4 QUALITY ASSURANCE

- 1.4.1 BAS Controls Contractor Qualifications:
 - 1.4.1.1 Contractor shall be an authorized dealer for the Unified Lighting Control System manufacturer products furnished.
 - 1.4.1.2 Contractor shall have an established office with experienced engineering and service personnel within a 100 km (60 mile) radius of the project site.
 - 1.4.1.3 Contractor shall have successfully completed the manufacturer's Technical Certification Training.
 - (1) Upon request, BAS Controls Contractor shall present record of completed training including course outlines and dated certificate.
 - 1.4.1.4 Contractor shall have a minimum 5 years of experience integrating lighting control systems with BACnet Building Automation Systems.
 - 1.4.1.5 Manufacturer shall have an established lighting control business that has been in continuous operation for more than 15 years.
 - 1.4.1.6 Manufacturer shall have a minimum of five (5) years of experience designing and manufacturing BACnet native lighting controls.
 - 1.4.1.7 Manufacturer shall provide, via web download, free firmware, and driver files during the warranty period.

1.5 CODES AND STANDARDS

- 1.5.1 Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:
 - 1.5.1.1 Ontario Electrical Safety Code (OESC).
 - 1.5.1.2 Ontario Building Code (OBC).
 - 1.5.1.3 ASHRAE 90.1-2013.
 - 1.5.1.4 National Electrical Manufacturer Association (NEMA).
 - 1.5.1.5 ANSI/ASHRAE 135-2010 Rev 12: Data Communication Protocol for Building Automation and Control Systems (BACNET)
 - 1.5.1.6 Underwriters Laboratory (UL) – UL916 Energy Management, UL508 Industrial Control Equipment, and UL924 Emergency Lighting and Power Equipment.

1.6 SUBMITTALS

- 1.6.1 The BAS Controls Contractor shall provide submittal drawings including the following:
 - 1.6.1.1 Bill of Material (BOM) list with item references
 - 1.6.1.2 Product data sheet for each item listed on the Bill of Material
 - 1.6.1.3 Communications riser diagram shall indicate the MAC address and BACnet Device ID for each BACnet native lighting controller that is part of the Unified Lighting Control System. The riser diagram shall also include the location and part number of each BACnet native lighting controller, and each BAS BACnet router.
 - 1.6.1.4 Panel and controller schedules shall indicate the circuit number, area description, and control sequence designation for each output.
 - 1.6.1.5 Written Sequence of Operation and BACnet Points List for each required Sequence of Operation
 - 1.6.1.6 Point-to-point wiring details for all inputs and outputs shall indicate the wiring and terminations.
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- 1.6.1.7 Addressable satellite and station network diagram for each lighting controller. The network diagram shall indicate the devices physical address, part number and location designation. The location designation shall include the lighting controllers BACnet Device ID, room number, switch box designation, and gang position.
- 1.6.1.8 Typical wiring diagrams for all items listed on the Bill of Material
- 1.6.1.9 Dimensional drawings of all items listed on the Bill of Material.
- 1.6.1.10 Written control sequences for each sequence of operation required.
- 1.6.1.11 Specification compliance statement.

1.7 CLOSEOUT SUBMITTALS

- 1.7.1 The BAS Controls Contractor shall provide as-built drawings including:
 - 1.7.1.1 Updated submittal drawings reflecting the actual installation of the system.
 - 1.7.1.2 Installation guides and user guides for each item list on the Bill of Material
 - 1.7.1.3 Operating and maintenance data.

1.8 WARRANTY

- 1.8.1 BAS Controls Contractor shall provide 24 month labor and material warranty on the complete Unified Lighting Control System. Warranty shall include all Centralized Panels, Distributed Controllers, Satellites, and low voltage field devices such as Stations, occupancy sensors, wall switches, and light level sensors. If within 24 months from the date of acceptance of the Unified Lighting Control System, upon written notice from the owner, it is found to be defective in operation, workmanship, or materials, it shall be replaced, repaired, or adjusted at the option of the BAS Controls Contractor.
- 1.8.2 Manufacturer shall provide a 24 month parts only warranty on the components provided. The warranty period shall commence after written owner acceptance and full payment is received by the Manufacturer. If within 24 months from the date of acceptance of the Unified Lighting Control System, upon written notice from the BAS Controls Contractor, it is found to be defective in operation, workmanship, or materials, it shall be replaced, repaired or adjusted at the option of the Manufacturer.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Basis of design is Unified Lighting Control System by Blue Ridge Technologies, Marietta GA (800-241-9173) furnished by the BAS Controls Contractor listed below:
- 2.1.2 Approved Manufacturer and BAS Controls Contractor:

<u>Manufacturer</u>	<u>BAS Controls Contractor</u>
Blue Ridge Technologies (basis of design).	AccuTemp Systems.
Honeywell Unitary Controller/Kele LDIM2 driver module.	Ace Solutions.
Approved equal.	Other City of Mississauga approved BAS vendors.

- 2.1.3 All proposed substitutions must be submitted in writing for approval by the design professional a minimum of ten (10) working days prior to the bid date. Submitted substitutions must be accompanied by a review of the specification noting compliance on a line-by-line basis.
 - 2.1.4 BAS Controls Contractor utilizing substitutions accept full responsibility for any associated costs directly related to substitution including but not limited to; required modifications to circuitry, devices, and wiring.
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2.2 MATERIALS

- 2.2.1 Provide new products the manufacturer is currently manufacturing and selling for use in new installations.
- 2.2.2 Manufacturer shall offer spare or equivalent parts for at least two years after completion of this contract. Spare parts include:
 - 2.2.2.1 Relays.
 - 2.2.2.2 Electronics.
 - 2.2.2.3 Transformers.
 - 2.2.2.4 Low Voltage Field Devices such as addressable stations, occupancy sensors, wall switches, and light level sensors
- 2.2.3 Manufacturer shall offer repair services or replacement parts for at least two years after shipment.

2.3 OPERATOR INTERFACE

- 2.3.1 Refer to Division 25 – Integrated Automation.
- 2.3.2 The Operator Interface furnished under Division 25 shall be the primary operator interface for the Unified Lighting Control System.
 - 2.3.2.1 All necessary operator functions, including scheduling, reporting, monitoring, overriding, etc., shall be provided through the Building Automation System operator workstations.
 - 2.3.2.2 Lighting floor plan graphics for switched lighting zones shall utilize the colour grey to represent Off, and the colour white to represent On.
 - (1) Dimmed lighting zones shall also utilize a numerical value (percentage) to represent the lighting intensity.

2.4 CENTRALIZED PANEL

- 2.4.1 BAS Controls Contractor shall provide Centralized Panels as detailed on drawings.
 - 2.4.1.1 The Electrical Contractor under Division 26 shall install Centralized Panels as detailed on the drawings and in accordance with the manufacturer's recommendation.
- 2.4.2 Panel shall include the BACnet native lighting controller, relays, transformer, voltage barriers, and other panel components.
- 2.4.3 Enclosure shall be manufactured with a minimum of 16 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated. Plastic enclosures are not acceptable.
- 2.4.4 Interior shall be manufactured with a minimum of 18 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated.
- 2.4.5 Panel shall be provided with control power transformer; 120 VAC or 277 VAC, 30 VA, 50/60 Hz.
 - 2.4.5.1 Control power transformer shall be an inherently limited.
 - 2.4.5.2 Optional 347 VAC control power transformer shall be available as required.
- 2.4.6 Panel shall be available in 08, 16, 32, 48, and 64 relay capacities, and shall accept any relay quantity between 1 and the maximum capacity of the panel.
- 2.4.7 Panel shall provide an odd / even relay number orientation that matches the layout of a standard circuit breaker panel.
- 2.4.8 Panel shall be provided with separate low voltage and line voltage compartments.
 - 2.4.8.1 Low voltage compartment, 16 relay capacity and greater, shall be accessed through a hinged door with a key.
 - 2.4.8.2 Low voltage compartment, 08 relay capacity, shall be accessed through a screw-on cover.

- 2.4.8.3 Access to the low voltage compartment (controller and low voltage terminations) shall not expose service personnel to the line voltage compartment, wiring, or terminations.
- 2.4.8.4 The line voltage compartment shall be accessed by removing dead-front cover.
- 2.4.8.5 Dead-front cover and line voltage compartments shall be properly marked.
- 2.4.8.6 Panels without dead-front covers are not acceptable.
- 2.4.8.7 Relay blanks shall be provided for each unpopulated relay slot in order to maintain proper voltage separation.
- 2.4.9 Panels, 16 relay capacity or greater, shall support optional relay voltage barriers to separate normal and emergency powered relays or to comply with other code requirements.
 - 2.4.9.1 Voltage barriers shall not reduce the relay capacity of the panel.
 - 2.4.9.2 Panels equipped for UL 924 shall include voltage barriers and the UL924 section shall be properly marked.
- 2.4.10 Enclosure, 08 relay capacity, shall be provided with a screw on cover.
- 2.4.11 Enclosure, 16 relay capacity or greater;
 - 2.4.11.1 Shall be provided with a hinged, lockable door. The hinged, lockable door shall be reversible in the field to allow left or right swing.
 - 2.4.11.2 Shall be available for rough-in
 - 2.4.11.3 Shall be provided with threaded studs for mounting the interior.
 - 2.4.11.4 Shall be available with optional flush doors for recess mounting.
- 2.4.12 Relay shall be a UL Listed component with a minimum Short Circuit Current Rating (SCCR) of 30,000 amps @ 277 VAC
- 2.4.13 Relay shall be SPST, dual-coil, latching relay with temporary override lever that indicates relay status.
 - 2.4.13.1 Electrically held or electrically latched relays are not acceptable
 - 2.4.13.2 HOA switch on relays are not acceptable.
- 2.4.14 Relay shall be rated for the following load ratings:
 - 2.4.14.1 Maximum of 20 amp Tungsten @ 347VAC
 - 2.4.14.2 Maximum of 30 amp Ballast @ 347VAC
 - 2.4.14.3 Maximum of 20 amp Resistive @ 347VAC
 - 2.4.14.4 1.5 Horse Power @ 120VAC
- 2.4.15 Relay shall be individually replaceable and shall directly connect to the relay interface board without soldering.
- 2.4.16 Relay shall be rated for a minimum of 300,000 on and off cycles at full load. Systems with published ratings less than 300,000 cycles at full load shall provide spare equipment and labor equal to the difference in their published life span cycles.

2.5 DISTRIBUTED CONTROLLER

- 2.5.1 BAS Controls Contractor shall provide Distributed Controllers as detailed on drawings.
 - 2.5.1.1 Electrical Contractor under Division 26 shall install Distributed Controllers as detailed on the drawings and in accordance with the manufacturer's recommendation.
 - 2.5.2 Distributed Controller shall include the BACnet native lighting controller, relays, transformer, voltage barriers, and other components.
 - 2.5.3 Distributed Controller shall be manufactured with a minimum of 20 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated. Plastic enclosures are not acceptable.
 - 2.5.4 Distributed Controller shall be provided with integral power supply feed by 120 VAC-277 VAC, 50/60 Hz.
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- 2.5.4.1 Controllers that require external transformer or power supply are not acceptable.
- 2.5.4.2 Optional 347 VAC shall be available as required.
- 2.5.5 Distributed Controller shall be plenum rated and shall mount to 4" square or 4-11/16" junction box.
- 2.5.6 Relay shall be SPST, dual-coil, latching relay with temporary override lever that indicates relay status.
 - 2.5.6.1 Electrically held or electrically latched relays are not acceptable.
 - 2.5.6.2 HOA switch on relays are not acceptable.
- 2.5.7 Relays shall be rated for the following load ratings:
 - 2.5.7.1 Maximum of 20 A Tungsten @ 120 VAC.
 - 2.5.7.2 Maximum of 20 A Ballast @ 277 VAC.
 - 2.5.7.3 Maximum of 20 A Resistive @ 277 VAC.
 - 2.5.7.4 2 hp @ 120 VAC.
 - 2.5.7.5 Relays with load ratings below 20 A are not acceptable.
- 2.5.8 Relay shall be rated for a minimum of 300,000 on and off cycles at full load. Systems with published ratings less than 300,000 cycles at full load shall provide spare equipment and labor equal to the difference in their published life span cycles.

2.6 BACNET NATIVE LIGHTING CONTROLLERS (BNLC)

- 2.6.1 BACnet Native Lighting Controllers (BNLC) inside Centralized Panels and Distributed Controllers shall be BACnet Advanced Application Controller (B-AAC) in accordance with BACnet Standardized Device Profile (Annex L), and shall comply with BACnet Protocol Revision 135-2010 Rev 12.
 - 2.6.2 BNLC shall be provided with BACnet MS/TP network communications.
 - 2.6.3 BNLC shall be provided with a micro-USB port for temporary connection to a laptop computer for product configuration.
 - 2.6.3.1 Connection shall support memory downloads, firmware upgrades and troubleshooting operations.
 - 2.6.3.2 Controller that requires proprietary cables are not acceptable.
 - 2.6.4 BNLC shall have the capability to read and write values to other BACnet controllers on the Building Automation System (BAS) BACnet MS/TP network.
 - 2.6.4.1 Control variables used to integrate control strategies across multiple BACnet controllers shall be readable by each BACnet controller on the network.
 - 2.6.5 BNLC shall have a real-time clock and shall utilize BACnet Universal Time Synchronization service.
 - 2.6.6 BNLC shall support all of the following BACnet Interoperability Building Blocks (BIBBs):
 - 2.6.6.1 Data Sharing – Read Property-B (DS-RP-B)
 - 2.6.6.2 Data Sharing – Read Property Multiple-A (DS-RPM-B)
 - 2.6.6.3 Data Sharing – Write Property-B (DS-WP-B)
 - 2.6.6.4 Data Sharing – Write Property Multiple-B (DS-WPM-B)
 - 2.6.6.5 Data Sharing – Change of Value-B (DS-COV-B)
 - 2.6.6.6 Data Sharing – Change of Value Unsolicited-B (DS-COVU-B)
 - 2.6.6.7 Scheduling – Internal-B (SCHED-I-B)
 - 2.6.6.8 Alarm and Event – Notification-Internal-B (AE-N-I-B)
 - 2.6.6.9 Alarm and Event – ACK-B (AE-ACK-B)
 - 2.6.6.10 Alarm and Event – Information-B (AE-INFO-B)
 - 2.6.6.11 Data Management – Dynamic Device Binding (DM-DDB-B)
 - 2.6.6.12 Data Management – Dynamic Object Binding (DM-DOB-B)
 - 2.6.6.13 Data Management – Device Communication Control (DM-DCC-B)
 - 2.6.6.14 Data Management – Time Synchronization (DM-TS-B)
 - 2.6.6.15 Data Management – UTC Time Synchronization (DM-UTC-B)
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- 2.6.7 BNLC shall provide a means to field select any one of the following BACnet baud rates; 9.6k, 19.2k, 38.4k, 76.8k or 115.2k.
- 2.6.8 BNLC shall provide a means to field select the MAC address and shall have a range from 1 to 127.
- 2.6.9 BNLC shall auto generate a BACnet Device ID that is based upon the selected MAC address and the manufacturer's BACnet Vendor ID.
 - 2.6.9.1 BNLC shall also be capable of being assigned a custom BACnet Device ID. The custom BACnet Device ID is assignable by the Building Automation System within the limits of the BACnet standard with a maximum value of 4,194,303.
- 2.6.10 BNLC shall be provided with a subnet port for optional Satellites and Stations.
 - 2.6.10.1 Subnet shall be free-topology network (stars and t-taps allowed).
 - 2.6.10.2 Systems requiring option cards are not acceptable.

2.7 LOW VOLTAGE INPUTS AND OUTPUTS

- 2.7.1 Centralized Panels, Distributed Controllers, and Satellites shall be provided with Universal Inputs (UI).
 - 2.7.1.1 UI shall be provided for direct connection to low voltage field devices such as dry contact switches, occupancy sensors, and light level sensors.
 - 2.7.1.2 Provide a minimum of;
 - (1) Twenty-four (24) each for Centralized Panels
 - (2) Six (6) each for Distributed Controllers
 - (3) Six (6) each for Satellites
 - 2.7.1.3 UI shall be field configurable as either a digital input or an analog input.
 - (1) Digital input shall be compatible with dry contact switches or occupancy sensors.
 - (2) Analog input shall be compatible with either 0-5 VDC, 0-10 VDC, or 4-20 mA.
- 2.7.2 Centralized Panels, Distributed Controller, and Satellite shall be provided with an integral 24 VDC, 200 mA supply for powering 24 VDC field devices connected to Universal Inputs (UI), or addressable stations connected to the subnet.
- 2.7.3 Distributed Controllers, and Satellites equipped with optional 0-10 VDC dimming capability shall be provided with Analog Outputs (AO).
 - 2.7.3.1 AO shall be provided for direct connection to 0-10Vdc dimming ballasts (Advance Mark 7 or equal).
 - 2.7.3.2 Provide a minimum of;
 - (1) Two (2) each for Distributed Controllers
 - (2) Two (2) each for Satellites
 - 2.7.3.3 AO shall be capable of sinking up to 100 mA, each
 - 2.7.3.4 AO shall be compatible with 0-10 VDC dimming ballasts that comply with IEC 60929 Annex E, Section E.2.
- 2.7.4 Distributed Controllers and Satellites shall be provided with two (2) line voltage switch inputs inside the line voltage compartment for use with line voltage wall switches or occupancy sensors.
 - 2.7.4.1 Line voltage switch input shall be field configurable as either a maintained or state change input.

2.8 SATELLITE

- 2.8.1 BAS Controls Contractor shall provide Satellites as detailed on drawings.
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- 2.8.1.1 Electrical Contractor under Division 26 shall install Satellite Controllers as detailed on the drawings and in accordance with the manufacturer's recommendation.
- 2.8.2 Satellite shall reside on the subnet of Centralized Panels and Distributed Controllers, and shall include the controller, relays, transformer, voltage barriers, and other components.
- 2.8.3 Satellite shall be manufactured with a minimum of 20 gauge cold rolled steel (C.R.S.) that is treated to prevent corrosion and is powder coated. Plastic enclosures are not acceptable.
- 2.8.4 Satellite shall be provided with integral power supply feed by 120 VAC-277 VAC, 50/60 Hz.
 - 2.8.4.1 Satellites that require an external transformer or power supply are not acceptable.
 - 2.8.4.2 Optional 347 VAC shall be available as required.
- 2.8.5 Satellite shall be plenum rated and shall mount to 4" square or 4 11/16" junction box.
- 2.8.6 Satellite relays shall be SPST, dual-coil, latching relay with temporary override lever that indicates relay status.
 - 2.8.6.1 Electrically held or electrically latched relays are not acceptable.
 - 2.8.6.2 HOA switch on relays are not acceptable.
- 2.8.7 Relays shall be rated for the following load ratings:
 - 2.8.7.1 Maximum of 20 A Tungsten @ 120 VAC.
 - 2.8.7.2 Maximum of 20 A Ballast @ 277 VAC.
 - 2.8.7.3 Maximum of 20 A Resistive @ 277 VAC.
 - 2.8.7.4 2.0 hp @ 120 VAC.
 - 2.8.7.5 Relays with load ratings below 20 A are not acceptable.
- 2.8.8 Relays shall be rated for a minimum of 300,000 on and off cycles at full load. Systems with published ratings less than 300,000 cycles at full load shall provide spare equipment and labor equal to the difference in their published life span cycles.
- 2.8.9 Satellite shall provide a means to field select the slot address.
 - 2.8.9.1 Up to 8 slots for Centralized Panels
 - 2.8.9.2 Up to 7 slots for Distributed Controllers

2.9 LOW VOLTAGE STATIONS

- 2.9.1 BAS Controls Contractor shall provide Stations as detailed on drawings.
 - 2.9.1.1 Electrical Contractor under Division 26 shall install and address all Stations as detailed on the drawings and in accordance with the manufacturer's recommendation.
 - 2.9.1.2 BAS Controls Contractor shall provide addressing and ganging information for all Stations.
 - 2.9.1.3 Electrical Contractor under Division 26 shall furnish and install all face plates with labeling or engraving as required. The BAS Controls Contractor shall provide the text for labeling or engraving of all face plates.
- 2.9.2 Stations shall be gang-able with other low voltage, decorator style devices under a common face plate.
- 2.9.3 Stations shall reside on a four (4) wire network (CL3P 22/4); two (2) for digital communication and two (2) for 24VDC power.
- 2.9.4 Stations shall be available in the following configurations:
 - 2.9.4.1 Channel On/Off - one (1), two (2), three (3), four (4), or six (6) button.
 - 2.9.4.2 Channel Raise/Lower - one (1), or two (2) channels.
 - 2.9.4.3 Preset – three (3) preset with raise/lower, or six (6) preset.
- 2.9.5 Stations shall be provided with LED indicator for status. LED On = Active or ON, LED Off = Inactive or OFF. LED shall also serve as a locator light by operating a low level that is

visible in a dark room. LED shall also be capable of blinking during the blink warning period.

- 2.9.6 Stations shall utilize capacitive touch technology.
 - 2.9.6.1 Stations with mechanical switches or moving parts are not acceptable.
- 2.9.7 Stations shall be available in white, black, grey, or light almond colours.
- 2.9.8 Stations utilizing pre-manufactured cables or proprietary wiring to connect to controllers are not acceptable.

2.10 LOW VOLTAGE OCCUPANCY SENSORS

- 2.10.1 BAS Controls Contractor shall provide Occupancy Sensors as detailed on drawings.
 - 2.10.1.1 Electrical Contractor under Division 26 shall install all Occupancy sensors as detailed on the drawings and in accordance with the manufacturer's recommendation.
 - 2.10.1.2 Electrical Contractor under Division 26 shall set all timers to the minimum setting and document settings on the as-built documents provided to the BAS Controls Contractor.
 - 2.10.1.3 Low voltage occupancy sensors that are not part of the Unified Lighting Control System shall be furnished and installed by the Electrical Contractor, under Division 26.
 - 2.10.2 Occupancy Sensors shall sense the presence of human activity within the desired space and provide a signal to the controller. The controller programming shall determine the on, off or dimming signals required to perform the sequences of operation in Part 3 Article "Sequence of Operations for Unified Lighting Controls."
 - 2.10.3 Occupancy Sensors shall utilize passive infrared (PIR) technology to detect occupant motion.
 - 2.10.4 For applications where a second method of sensing is necessary to adequately detect or maintain occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.
 - 2.10.5 Acceptable dual technology includes;
 - 2.10.5.1 PIR/Microphonics (also known as Passive Dual Technology or PDT)
 - 2.10.5.2 PIR/Ultrasonic
 - 2.10.6 All sensing technologies provided shall not interfere with other electronic devices within the space (such as electronic white board readers or hearing aids). Microwave based sensing technologies are not acceptable for use within the building envelope.
 - 2.10.7 Occupancy Sensors shall be 24 VDC with three (3) wire (common, power, and signal), or four (4) wire (common, power, signal common, and signal) connections and shall be available for the following applications:
 - 2.10.7.1 Ceiling Mount Passive Infrared – OSCM-9-R or equal
 - 2.10.7.2 Ceiling Mount Passive Dual Tech – OSCM-PDT-9-R or equal
 - 2.10.7.3 Wall Mount Passive Infrared – OSWV-16-R or equal
 - 2.10.7.4 Wall Mount Passive Dual Tech – OSWV-PDT-R or equal
 - 2.10.7.5 Hallway Passive Infrared – OSHW-13-R or equal
 - 2.10.7.6 Wall Switch Passive Infrared – OSWS-LV-R or equal
 - 2.10.7.7 Wall Switch Passive Dual Tech – WS-LV-PDT-R or equal
 - 2.10.8 Occupancy Sensors with automatic time delay adjustments are not acceptable. The controller shall determine the occupancy sensor time delay, minimum on time or other timing parameters.
 - 2.10.9 Occupancy sensors shall have a minimum timer value of 30 seconds or less.
 - 2.10.10 Occupancy Sensor shall be factory calibrated for optimum performance for its installed PIR lens, and shall not require initial or subsequent field adjustment of detection sensitivity.
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- 2.10.11 Occupancy Sensors with integral light sensor are not acceptable.
- 2.10.12 Occupancy Sensors utilizing pre-manufactured cables or proprietary wiring to connect to controller are not acceptable.

2.11 LOW VOLTAGE WALL SWITCHES

- 2.11.1 BAS Controls Contractor shall provide Wall Switches as detailed on drawings.
 - 2.11.1.1 Electrical Contractor under Division 26 shall install all Wall Switches as detailed on the drawings and in accordance with the manufacturer's recommendation.
 - 2.11.1.2 Electrical Contractor under Division 26 shall furnish and install all face plates with labeling or engraving as required. The BAS Controls Contractor shall provide the text for labeling or engraving of all face plates.
 - 2.11.1.3 Low voltage wall switches that are not part of the Unified Lighting Control System shall be furnished and installed by the Electrical Contractor, under Division 26.
- 2.11.2 Wall Switches shall be gang-able with other low voltage, decorator style devices under a common face plate.
- 2.11.3 Wall Switches utilizing pre-manufactured cables or proprietary wiring to connect to controllers are not acceptable.

2.12 LOW VOLTAGE LIGHT LEVEL SENSORS

- 2.12.1 BAS Controls Contractor shall provide low voltage Light Level Sensors as detailed on drawings.
 - 2.12.1.1 Electrical Contractor under Division 26 shall install all Light Level Sensors as detailed on the drawings and in accordance with the manufacturer's recommendation.
- 2.12.2 Light Level Sensors shall be a 3 wire (common, power and signal) analog, linear photo diode and shall be available for the following applications:
 - 2.12.2.1 Indoor, 0-100 fc, 0-50 fc, or 0-25 fc.
 - 2.12.2.2 Outdoor, 0-250 fc, 0-50 fc, or 0-25 fc.
 - 2.12.2.3 Atrium, 0-1,000 fc.
 - 2.12.2.4 Skylight, 0-2,000 fc.
- 2.12.3 Light Levels Sensors that require an interface box, manual set points, or external power source are not acceptable.
- 2.12.4 Light Level Sensors utilizing pre-manufactured cables or proprietary wiring to connect to controllers are not acceptable.

2.13 LINE VOLTAGE OCCUPANCY

- 2.13.1 BAS Controls Contractor shall provide line voltage occupancy sensors that are directly connected to the Unified Lighting Control System.
 - 2.13.1.1 Electrical Contractor under Division 26 shall install all line voltage occupancy sensors as detailed on the drawings and in accordance with the manufacturer's recommendation.
- 2.13.2 Line voltage occupancy sensors that are not part of the Unified Lighting Control System shall be furnished and installed by the Electrical Contractor, under Division 26.

2.14 LINE VOLTAGE SWITCHES

- 2.14.1 All line voltage switches shall be furnished and installed by the Electrical Contractor, under Division 26.
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2.15 TECHNICIANS KIT

- 2.15.1 BAS Controls Contractor shall provide Technicians Kit to owner during training. The Technicians Kit shall include;
 - 2.15.1.1 Configuration software on USB flash drive
 - 2.15.1.2 USB Cable (micro-B
 - 2.15.1.3 Bluetooth USB Dongle
 - 2.15.1.4 Bluetooth Module
- 2.15.2 BAS Controls Contractors shall provide an electronic copy of all system files and firmware images for all BACnet Native Lighting Controllers (BNLC).
- 2.15.3 Configuration software shall be capable of local communication with one or multiple BNLC using USB (or optional Bluetooth). Upon local connection with one BNLC the software shall be capable of communication with any other BNLC on that BACnet MSTP segment / LAN.
- 2.15.4 Configuration software shall be capable of remote communication with one or multiple BNLC using IP connection through the BACnet IP / MSTP router (BACnet router must support tunneling). Upon remote connection with one BNLC the software shall be capable of communication with any other BNLC on that BACnet MSTP segment / LAN.
- 2.15.5 Configuration software shall be capable of setting or changing all BNLC parameters.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Installation of Unified Lighting Control Systems shall be furnished by the Electrical Contractor under Division 26.

3.2 PROGRAMMING AND CONFIGURATION

- 3.2.1 BAS Controls Contractor under this Section shall program and configure Unified Lighting Control System controllers to perform the functions in Part 3 Article "Sequence of Operations for Unified Lighting Controls."
- 3.2.2 BAS Controls Contractor shall configure the Unified Lighting Control System to be an integral part of the Building Automation System such that the operator experiences one unified system of controlling, monitoring, scheduling, trending, alarming, etc.
- 3.2.3 BAS Controls Contractor shall provide an operator interface that includes the following graphics:
 - 3.2.3.1 Floor Plan Graphic: Each controlled zone shall be represented on a Floor Plan Graphic. The status shall be represented on the graphic using colour.
 - (1) Grey shall represent Off.
 - (2) White shall represent On.
 - (3) Areas with dimming, multiple levels or presets shall also have an adjacent numeric value showing the current percentage or active preset.
 - 3.2.3.2 Zone Detail Graphic. Each zone shall have a Zone Detail Graphic displaying the following:
 - (1) Status of channel(s) associated with the Zone. Status shall be represented on the graphic using colour.
 - (2) Status of channel timer values for override switches or occupancy sensors associated with the channel. The time-out value shall be represented in minutes and seconds.

- (3) Status of channel runtime and cycle count. The runtime shall be represented in hours and minutes. The cycle count shall be represented as a numeric value.

- 3.2.4 Provided that the operator has the appropriate access, each Zone shall be able to be commanded from the Floor Plan Graphic.

3.3 CONTROL SYSTEM CHECKOUT AND TESTING

- 3.3.1 BAS Controls Contractor shall complete startup testing to verify operational control system before notifying Owner of system demonstration.
 - 3.3.1.1 Provide Owner with schedule for startup testing. Owner may have representative present during any or all startup testing.
 - 3.3.1.2 Verify that control wiring is properly connected.
 - 3.3.1.3 Validated that wiring installed by Division 26 is free of shorts and ground faults, and that terminations are tight.
 - 3.3.1.4 Verify that system performs the functions as referenced in Part 3 Article "Sequence of Operations for Unified Lighting Controls."
 - 3.3.1.5 Simulate and observe each operational mode by overriding and varying inputs and schedules.
 - 3.3.1.6 Check each alarm with an appropriate signal at a value that will trip the alarm.
 - 3.3.1.7 Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.

3.4 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- 3.4.1 After tests described in this specification are performed to the satisfaction of both Engineer and Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test.
- 3.4.2 System shall not be accepted until completed demonstration forms and checklists are submitted and approved.

3.5 TRAINING

- 3.5.1 BAS Controls Contractor shall provide two (2) four (4) hour sessions of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the Unified Lighting Control System software, layout and naming conventions, and a walk through of the facility with the facility manager to identify Centralized Panels, Distributed Controllers, Satellite Controllers, and low voltage field devices and locations.

3.6 SEQUENCE OF OPERATION FOR UNIFIED LIGHTING CONTROLS

- 3.6.1 In accordance with lighting controls matrix drawing E-605.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Building Automation System integration requirements related to electrical systems.

1.2 RELATED REQUIREMENTS

- 1.2.1 Division 26 – Electrical.

2 PRODUCTS

2.1 POINTS SPECIFIED BUT NOT DESCRIBED IN SEQUENCES

- 2.1.1 Any remaining points not detailed in this section are to be monitored and available for trending data.

2.2 SECTION 26 27 13 – ELECTRICITY METERING

- 2.2.1 Customer meters to building automation system.

2.3 SECTION 26 32 13.16 – GAS-ENGINE-DRIVEN GENERATOR SETS

- 2.3.1 Connect all generator alarm and status contacts.

2.4 SECTION 26 36 23.13 – BYPASS-ISOLATION AUTOMATIC TRANSFER SWITCHES

- 2.4.1 Connect all transfer switch alarms and status contacts.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 In accordance with Section 25 05 01 and Section 25 05 02.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Common requirements for electrical work.
- 1.1.2 Mounting heights for electrical equipment and devices.

1.2 RELATED REQUIREMENTS

- 1.2.1 Provisions of this section apply to all sections of Division 26, Division 27, and Division 28.
- 1.2.2 Section 07 62 00 – Metal Flashing.
- 1.2.3 Section 07 84 00 – Firestopping and Smoke Seals.
- 1.2.4 Section 08 31 00 – Access Doors and Panels.
- 1.2.5 Section 09 91 00 – Painting.
- 1.2.6 Section 11 11 36 – Vehicle Charging Equipment.
- 1.2.7 All sections related to heat tracing.
- 1.2.8 Building Automation System integration requirements for Electrical Systems as described in Section 25 56 50, and Section 25 96 00.
- 1.2.9 This section is to be read in conjunction with Division 00 documents, and Division 01 specification sections, which take precedence as described in CCDC 2-2020.
 - 1.2.9.1 General Conditions.
 - 1.2.9.2 Supplementary General Conditions.
 - 1.2.9.3 General Requirements.

1.3 INTENT

- 1.3.1 Include all material, labour, equipment, and plant construction as necessary to make a complete installation as shown and specified hereinafter.
- 1.3.2 Leave complete systems ready for continuous and efficient satisfactory operation.
- 1.3.3 Discipline and Trade Jurisdiction:
 - 1.3.3.1 In accordance with CCDC 2-2020 GC 1.1.9: Neither the organization of the Specifications nor the arrangement of Drawings shall control the Contractor in dividing the work among Subcontractors and Suppliers.
 - 1.3.3.2 MasterFormat's organizational structure used in a project manual does not imply how the work is assigned to various design disciplines, trades, or subcontractors. MasterFormat is not intended to determine which particular elements of the project manual are prepared by a particular discipline. Similarly, it is not intended to determine what particular work required by the project manual is the responsibility of a particular trade. A particular discipline or trade is likely to be responsible for subjects from multiple Divisions, as well as from multiple Subgroups.

1.4 DRAWINGS AND SPECIFICATIONS

- 1.4.1 The drawings and specifications are complementary each to the other and what is called for by one to be binding as if called for by both. Should any discrepancy appear between the drawings and specifications, which leaves the Contractor in doubt as to the true intent and meaning of plans and specifications, a ruling is to be obtained from the Consultant in writing before submitting Bid. If this is not done, the maximum, the most expensive alternate or option will be provided in base tender bid.
 - 1.4.2 All drawings and all Divisions of these specifications shall be considered as a whole, and work of this Division shown anywhere therein shall be furnished under this Division.
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- 1.4.3 Drawings are diagrammatic and indicate the general arrangement of equipment and pathways. Most direct routing of conductors and wiring is not assured. Exact requirements are governed by architectural, structural, and mechanical conditions of the job. Consult all other drawings in preparation of the bid. Extra lengths of wiring or addition of pull and junction boxes, etc. necessitated by such conditions are to be included in the bid. Check all information and report and apparent discrepancies before submitting the bid.
 - 1.4.4 Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pathways so as to best fit the layout of the job. Plan, coordinate, and establish exact locations and routing of services with affected trades prior to installation such that services clear each other, as well as other obstructions.
 - 1.4.5 Determine final locations of major work within ceiling spaces based on the largest equipment first.
 - 1.4.6 Unless otherwise shown or specified, conceal work in finished areas, and conceal work in partially finished and/or unfinished areas to extent made possible by the area construction. Install services as high as possible to conserve headroom and/or ceiling space. Notify the Consultant where headroom or ceiling space appears to be inadequate prior to installation of the work.
 - 1.4.7 Scaling off the drawings will not be sufficient or accurate for determining these locations. Where job conditions require reasonable changes in indicated arrangement and locations, such changes shall be made at no additional cost to the Owner.
 - 1.4.8 Because of the scale of the drawings, certain basic items, such as junction boxes, pull boxes, conduit fittings, etc. may not be shown, but where such items are required by other sections of the specifications or where there are required for proper installation of the work, such items are to be furnished and installed.
 - 1.4.9 Before ordering any conduit, cable tray, conductors, wireways, raceway bus duct, fittings, etc., verify all pertinent dimensions at the job site and be responsible for their accuracy.
 - 1.4.10 If obvious ambiguities or omissions are noticed when tendering refer same to the Consultant for a ruling and obtain the ruling in writing in the form of an Addendum. Claims for extras for ambiguities or omission of items brought to the attention of the Consultant after the award of a contract which, due to the nature of the ambiguity or omission, should have been brought to the attention of the Consultant during the tendering period, will not be allowed.
 - 1.4.11 The drawings are performance drawings, diagrammatic, and show locations for apparatus and materials. The drawings are intended to convey the scope of work and do not intend to show Architectural and Structural details. The locations shown are approximate, and may be altered, when approved by the Consultant, to meet requirements of the material and/or apparatus, other equipment and systems being installed, and of the building. Do not scale drawings.
 - 1.4.12 Control devices, equipment requiring maintenance, junction boxes, and similar products, particularly such products located above suspended ceilings must be located for easy access for servicing and/or removal. Products which do not meet this location requirement are to be relocated to an accessible location at no additional cost.
 - 1.4.13 Be responsible for making necessary changes, at no additional cost, to accommodate structural and building conditions that were foreseeable by a review of existing conditions or a review of drawings prepared by other disciplines.
 - 1.4.14 Where drawings indicate that acoustic tile ceiling is being suspended below existing plaster ceilings, coordinate the design of framework used to support this suspended ceiling, lighting, diffusers, and other components that are mounted within or through ceiling. Do not mount devices to suspended ceilings. Secure and mount to ceiling slab above. Seal ceiling openings to maintain required fire rating.
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- 1.4.15 Provide any fitting, offset, transformation, etc., required to suit architectural and structural details but not shown.

1.5 WORK RESTRICTIONS

- 1.5.1 Refer to Section 01 10 00.
- 1.5.2 Do all cutting, patching, and making good to leave in a finished condition and to make the several parts of the Work come together properly. Co-ordinate work to keep cutting and patching to a minimum.
- 1.5.3 Quality of workmanship and materials used in patching, making good and refinishing of existing construction and/or compartments shall be of a standard equal to that specified for new construction and if not specified, equal to or exceeding that of original existing work.
- 1.5.4 Prior to cutting openings, examine wall, floor, and ceiling construction for buried electrical cables and pipes; and take adequate protection. Conduct cable locating tests to locate buried cables in existing work.

1.6 ALLOWANCES

- 1.6.1 Cash allowances are to be carried as indicated in Section 01 21 13 for the items indicated, each including all equipment, wiring material, labour, incidentals, profit, overhead, taxes, etc.
- 1.6.2 Conduit and wireway rough-in for systems noted as Allowances is part of this contract, and is excluded from the above allowances.

1.7 SUBSTITUTION PROCEDURES

- 1.7.1 Refer to Section 01 25 13
 - 1.7.2 Additionally, "Approved equal" shall be defined as a substitution approved by the Consultant.
 - 1.7.3 If during the tender bid process, the bidding contractor wishes to substitute the specified equipment for an "Approved equal", the bidding contractor must submit shop drawings to the Consultant before the tender close for approval. If no substitution request is made, the as-specified equipment is that to be provided.
 - 1.7.4 Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required to be used in this contract.
 - 1.7.5 This contractor, at his option, may use equipment as manufactured by any of the listed manufacturers. This Contractor is responsible to ensure that all items submitted by these other manufacturers meets are requirements of the drawings and specification and fits in the allocated space. The final determination of a product being equivalent is to be determined by the Consultant when a catalog number is not listed, or listed in part.
 - 1.7.6 Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Consultant as described in the General Provisions of the Contract for Submittals. The Contractor bears full responsibility for the unnamed manufacturers' equipment adequately meeting the intent of the design. The Owner or the Consultant may reject manufacturer at time of shop drawing submittal.
 - 1.7.7 In addition to manufacturer's products base specified or named as acceptable, other manufacturers of products may be proposed as substitutions to the Consultant for review and consideration for acceptance, listing in each case a corresponding credit for each substitution proposed. However, base Bid Price on products base specified or named as acceptable. Certify in writing to the Consultant that proposed substitution meets space,
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power, design, energy consumption, and other requirements of base specified or acceptable product. It is understood that there will be no increase in Contract Price by reason of any changes to associated equipment, mechanically, electrically, structurally, or architecturally, required by acceptance of proposed substitution. The Consultant has sole discretion in accepting any such proposed substitution of product. Indicate any proposed substitutions in areas provided on Bid Form. Do not order such products until they are accepted in writing by the Consultant.

1.8 CONTRACT MODIFICATION PROCEDURES

- 1.8.1 Refer to Section 01 26 00.
- 1.8.2 Whenever the Consultant proposes in writing to make a change or revision to design, arrangement, quantity, or type of work from that required by Contract Documents, prepare, and submit to the Consultant for review, a quotation being proposed cost for executing change or revision.
- 1.8.3 Quotation is to be a detailed and itemized estimate of product, labour, and equipment costs associated with change or revision, plus overhead and profit percentages and applicable taxes and duties.
- 1.8.4 Unless otherwise specified in Division 00, Division 01, or as identified in the Owner/Contractor agreement, allowable maximum percentages for overhead and profit are to be 7% and 5% respectively.
- 1.8.5 Unless otherwise specified in Division 00, or Division 01, following additional requirements apply to all quotations submitted:
 - 1.8.5.1 When change or revision involves deleted work as well as additional work, cost of deleted work (less overhead and profit percentages but including taxes and duties) is to be subtracted from cost of additional work before overhead and profit percentages are applied to additional work.
 - 1.8.5.2 Electrical material labour unit costs are to be in accordance with National Electrical Contractors Association (NEMA) Manual of Labor Units (MLU), less 25%.
 - 1.8.5.3 Costs for journey person and apprentice labour must not exceed prevailing rates at time of execution of Contract and must reflect actual personnel performing work.
 - 1.8.5.4 Cost for site superintendent must not exceed 10% of total hours of labour estimated for change or revision, and change or revision must be such that site superintendent's involvement is necessary.
 - 1.8.5.5 Overhead percentage will be deemed to cover quotation costs other than actual site labour and materials, and rentals.
 - 1.8.5.6 Quotations, including those for deleted work, to include a figure for any required change to Contract time.
- 1.8.6 The Consultant reserves the right to request backup quotations for any materials and/or rentals included within the quotation.
- 1.8.7 Quotations submitted that are not in accordance with requirements specified above will be rejected and returned for re-submittal. Failure to submit a proper quotation to enable Consultant to expeditiously process quotation and issue a Change Order will not be grounds for any additional change to Contract time.
- 1.8.8 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.
- 1.8.9 Do not execute any change or revision until written authorization for the change or revision has been obtained from the Consultant.

1.9 COORDINATION

- 1.9.1 Refer to Section 01 31 13.
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- 1.9.2 Coordinate work with other trades to avoid conflict and to provide correct rough-in and connection for equipment furnished under other trades that require electrical connection. Inform Contractors of other trades of the required access to and clearances around electrical equipment to maintain serviceability and code compliance.
- 1.9.3 Verify equipment dimensions and requirements with provision specified under this Section. Check actual job conditions before fabricating work. Report necessary changes in time to prevent needless work. Changes or additions subject to additional compensation, which are made without written authorization and an agreed price, shall be at Contractor's risk and expense.
- 1.9.4 Read specifications and drawings of other trades and conform with their requirements before proceeding with any work specified in this Division related to other trades. Co-operate with all other trades on the job, so that all equipment can be satisfactorily installed, and so that no delay is caused to any other trades.
- 1.9.5 Coordinate utility service outages with the owner. Obtain permission from Owner at least 24 hours before partially or completely disabling system. Minimize outage duration.
- 1.9.6 Co-ordinate work with all trades to ensure a proper and complete installation. Notify all trades concerned of the requirement for openings, sleeves, inserts, and other hardware necessary for the installation and, where work is to be integrated with the work of other trades or is to be installed in close proximity with the work of other trades, carefully co-ordinate the work prior to installation.
- 1.9.7 Working Detail Drawings
 - 1.9.7.1 The contractor is to prepare working detail drawings supplementary to the contract drawings, when deemed necessary by the Consultant, for all areas where a multiplicity of materials and or apparatus occur, or where the work due to architectural and structural considerations involves special study and treatment. Such drawings may be prepared jointly by all trades affected, or by the one trade most affected with due regard for and approval of the other trades, all as the Consultant will direct in each instance. Such drawings must be reviewed by the Consultant before the affected work is installed.
 - 1.9.7.2 Carry out all alterations in the arrangement of work which has been installed without proper study and approval, even if in accordance with the contract documents, in order to make such work come within the finished lines of walls, floors and ceilings, or to allow the installation of other work, without additional cost. In addition, make any alterations necessary in other work required by such alterations, without additional cost.

1.10 SUBMITTAL PROCEDURES

- 1.10.1 Refer to Section 01 33 00.
 - 1.10.2 Before delivery to site of any item of equipment, submit shop drawings complete with all data, pre-checked and stamped accordingly, for review by the Consultant. Indicate project name on each brochure or sheet, make reference to the number and title of the appropriate specification section, type identifier such panelboard ID or luminaire type as indicated on appropriate schedule, and provide adequate space to accommodate the Consultant's review stamp(s).
 - 1.10.3 Verify field measurements and affected adjacent Work are coordinated, including passageway clearances for movement of equipment into location.
 - 1.10.4 Submit shop drawings to the Consultant in electronic (PDF) format, as coordinated after award of contract. Where submittals are derived from digital originals, do not print and rescan documents; submittals made as such will be immediately rejected.
 - 1.10.5 Submit a schedule of shop drawings within one week after award of contract. Group submittals by specification division as appropriate.
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1.10.6 Shop Drawings

1.10.6.1 Submit for review, properly identified shop drawings showing in detail the design and construction of all equipment and materials as requested in sections of the specification governed by this Section.

1.10.6.2 Obtain and comply with the manufacturer's installation instructions.

1.10.6.3 Endorse each shop drawing copy "CERTIFIED TO BE IN ACCORDANCE WITH ALL REQUIREMENTS", stamp each copy with your company name, date each copy with the submittal date, and sign each copy. Shop drawings which are received and are not endorsed, dated, and signed will be returned for re-submittal.

1.10.6.4 The Consultant will stamp shop drawings as follows:

(1) Reviewed ()

(2) Reviewed as Modified ()

(3) Revise and Re-Submit ()

(4) Not Reviewed ()

1.10.6.5 If "REVIEWED" is checked-off, the shop drawing is satisfactory. If "REVIEWED AS MODIFIED" is checked-off, the shop drawing is satisfactory subject to requirements of remarks put on shop drawing copies. If "REVISE AND RE-SUBMIT" is checked-off, the shop drawing is entirely unsatisfactory and must be revised in accordance with comments written on shop drawing copies and resubmitted. If "NOT REVIEWED" is checked-off, the shop drawing is in error of submission, not applicable for this project.

1.10.6.6 This review by the Consultant is for the sole purpose of ascertaining conformance with the general design concept. This review shall not mean that the Consultant approved the detail design inherent in the shop drawings, responsibility for which shall remain with the Contractor, and such review shall not relieve the Contractor of responsibility for errors or omissions in the shop drawings or of responsibility for meeting all requirements of the contract documents. Be responsible for dimensions to be confirmed and correlated at the job site, for information that pertains solely to fabrication processes or to techniques of construction and installation, and for co-ordination of the work as well as compliance with codes and inspection authorities such as CSA, etc.

1.10.7 Confirm layouts of major electrical equipment rooms with the dimensions of as-procured equipment, and submit a layout sketch to the Consultant showing the major equipment and required clear spaces. The contractor may, at their option, revise the layout of the major electrical equipment rooms, but take responsibility for these new layouts and meeting the requirements of the local electrical utilities. Capture final room layouts on as-built drawings.

1.11 SUBMITTALS

1.11.1 The Contractor is to submit dimensioned drawings or sketches that indicates the dimensions of the procured equipment, demonstrates that the equipment will fit in the allocated spaces, and demonstrates that manufacturer and code required clear spaces are provided.

1.11.2 Include sketches for the following locations that includes at minimum, major equipment such as switchboards, panelboards, splitters, transformers, generators, transfer switches, major wall mounted or floor mounted telecommunications equipment, and fire alarm panels, passive graphics, and annunciator panels.

1.11.2.1 Main Electrical Room.

1.11.2.2 Telecommunications rooms.

1.11.2.3 Mechanical rooms (layouts to be coordinated with mechanical trade).

1.11.2.4 Area around outdoor generator enclosure.

1.12 SAFETY REQUIREMENTS

- 1.12.1 Refer to Section 01 35 29.
- 1.12.2 Be responsible for the safety of workers and the equipment on the project in accordance with all applicable safety legislation passed by Federal, Provincial, and local authorities governing construction safety. The more stringent regulations prevail.

1.13 REGULATORY REQUIREMENTS

- 1.13.1 Refer to Section 01 41 00.
- 1.13.2 Codes and Standards
 - 1.13.2.1 Ontario Electrical Safety Code including all bulletins and amendments.
 - 1.13.2.2 Ontario Building Code and its referenced standards.
 - 1.13.2.3 Applicable CSA and ULC standards.
 - 1.13.2.4 All work shall be in accordance with Owner's Design Guidelines.
- 1.13.3 Permits and Fees
 - 1.13.3.1 Obtain and pay for all permits and fees required for the execution and inspection of the electrical work and pay all charges incidental to such permits. Submit to Electrical Inspection Department and Supply authority necessary number of drawings and specifications for examination and approval prior to commencement of work. Arrange and pay for any special inspection of equipment specified if and when required.
 - 1.13.3.2 Apply, pay and obtain all permits as required for the electrical work.
 - 1.13.3.3 Upon substantial completion of your work, supply and turn over to the Consultant all required inspection certificates from governing authorities to certify that the work as installed conforms to the rules and regulations of the governing authorities.
- 1.13.4 Patents
 - 1.13.4.1 Pay all royalties and licence fees, and defend all suits or claims for infringement of any patent rights, and save the Owner, Architect, Project Manager and Consultants harmless of loss or annoyance on account of suit, or claims of any kind for violation or infringement of any letters patent or patent rights, by this Subcontractor or anyone directly or indirectly employed by him or by reason of the use by him or them of any part, machine, manufacture or composition of matter on the work, in violation or infringement or such letters patent or rights.

1.14 REFERENCES

- 1.14.1 CSA Group:
 - 1.14.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.14.1.2 CSA C235:19, Preferred voltage levels for AC Systems up to 50 000 V.
 - 1.14.1.3 Do underground systems in accordance with CSA C22.3 No. 7-15, Underground systems, except where specified otherwise.
 - 1.14.1.4 Ontario Electrical Safety Code (28th edition/2021), and all bulletins.
 - 1.14.2 Electrical and Electronic Manufacturer's Association of Canada (EEMAC)
 - 1.14.2.1 EEMAC 2Y-1-1958, Light Gray Colour for Indoor Switch Gear.
 - 1.14.3 Health Canada / Workplace Hazardous Materials Information System (WHMIS)
 - 1.14.3.1 Material Safety Data Sheets (MSDS).
 - 1.14.4 Electrical utility requirements and local applicable codes and regulations.
 - 1.14.5 Institute of Electrical and Electronics (IEEE)/National Electrical Safety Code Product Line (NESC)
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1.14.5.1 IEEE SP1122-2000, The Authoritative Dictionary of IEEE Standards Terms, 7th Edition.

1.14.6 2012 Ontario Building Code.

1.14.7 CAN/ULC-S1001-11, Integrated Systems Testing of Fire Protection and Life Safety Systems.

1.15 DEFINITIONS

1.15.1 Electrical and electronic terms: unless otherwise specified or indicated, terms used in these specifications, and on drawings, are those defined by IEEE SP1122.

1.16 QUALITY ASSURANCE

1.16.1 Refer to Section 01 45 00.

1.16.2 The specifications contained herein are set forth as the minimum acceptable requirements. This does not relieve the Contractor from executing other quality assurance measures to obtain a complete operating system within the scope of this project.

1.16.3 Ensure that all workmanship, all materials employed, all required equipment and the manner and method of installation conforms to accepted construction and engineering practices, and that each piece of equipment is in satisfactory working condition to satisfactorily perform its functional operation.

1.16.4 Provide quality assurance tests and operational check on all components of the electrical distribution system, all lighting fixtures, and communication systems.

1.16.5 Only first class workmanship will be accepted, not only in regards to durability, efficiency and safety, but also in regards to neatness of detail. Present a neat and clean appearance on completion to the satisfaction of the Consultant. Any unsatisfactory workmanship will be replaced at no extra cost.

1.16.6 Conform to the best practices applicable to this type of work. Install all equipment and systems in accordance with the manufacturer's recommendations, but consistent with the General Requirements of this specification. Electrical Contractor will be held responsible for all damage to the work of his own or any other trade, resulting from the execution of his work. Store all electrical equipment and materials in dry locations.

1.16.7 Provide foreman in charge of this work at all times.

1.16.8 The contractor shall be fully liable to provide and maintain in force during the life of this Contract, such insurance, including Public Liability Insurance, Product Liability Insurance, Auto Liability Insurance, Worker's Compensation, and Employer's Liability Insurance.

1.16.9 Governing Federal, Provincial and Municipal codes and regulations will be considered minimum standards for the work and where these are at variance with the drawings and specification, the more stringent ruling will apply.

1.16.10 Where any code, regulation, bylaw, or standard is quoted it shall mean the current edition including all revisions or amendments at the time of the tender.

1.16.11 In case of conflict, the codes and regulations take precedence over the Contract Documents. In no instance reduce the standard or scope of work or intent established by the drawings and specifications by applying any of the codes referred to herein.

1.17 QUALITY CONTROL

1.17.1 Refer to Section 01 45 00.

1.17.2 Provide a full time Superintendent to oversee and coordinate all sub-trades in these divisions.

1.18 TEMPORARY UTILITIES

- 1.18.1 Refer to Section 01 50 00.
- 1.18.2 Do not use any of the permanent facility systems during construction except as may be specified, or unless written approval is obtained from the Consultant.
- 1.18.3 The use of permanent facilities for temporary construction service will not affect in any way the commencement day of the warranty period.
- 1.18.4 Temporary heating during the construction period will be provided as described in Division 01.

1.19 PRODUCT REQUIREMENTS

- 1.19.1 Refer to Section 01 60 00.
 - 1.19.2 The design, manufacture and testing of electrical equipment and materials shall conform to or exceed the latest applicable CSA, IEEE, and ANSI standards.
 - 1.19.3 All materials must be new and be ULC or CSA listed. Any materials not covered by the aforementioned listing standards shall be tested and approved by an independent testing laboratory, Technical Inspection Services, or other government agency.
 - 1.19.4 Materials and equipment are specifically described and named in this Specification in order to establish a standard of material and workmanship.
 - 1.19.5 Materials required for performance of work shall be new and the best of their respective kinds and of uniform pattern throughout work.
 - 1.19.6 Materials shall be of Canadian manufacture where obtainable. Materials of foreign manufacture, unless specified, shall be approved before being used.
 - 1.19.7 Equipment items shall be standard products of approved manufacturers. Identical units of equipment shall be of same manufacturer. In any unit of equipment, identical component parts shall be of same manufacturer, but the various component parts comprising the unit need not be of one manufacturer.
 - 1.19.8 Chemical and physical properties of materials and design performance characteristics and methods of construction and installation of items of equipment, specified herein, shall be in accordance with latest issue of applicable Standards or Authorities when such are either mentioned herein, or have jurisdiction over such materials or items of equipment.
 - 1.19.9 Materials shall bear approval labels as required by Code and/or Inspection Authorities.
 - 1.19.10 Install materials in strict accordance with manufacturer's recommendations.
 - 1.19.11 Include items of material and equipment not specifically noted on Drawings or mentioned in Specification but which are necessary to make a complete and operating installation.
 - 1.19.12 Remove materials, condemned as not approved for use, from job site and deliver and install suitable approved materials in their place.
 - 1.19.13 Unless otherwise noted, equipment and material specifications in Sections of the Specification governed by this Section are based on products of a manufacturer selected by the Consultant for the purpose of setting a standard of quality, size, performance, capacity, appearance, and serviceability.
 - 1.19.14 In most instances the names of acceptable manufacturers are also stated for materials and equipment, and you may base your tender price on equipment and materials produced by either the specified manufacturer or a manufacturer listed as acceptable.
 - 1.19.15 For any items of equipment, material, or for any system where acceptable manufacturers are not stated, you must provide only the equipment, material or system specified.
 - 1.19.16 If materials or equipment manufactured and/or supplied by a manufacturer named in the specifications are used in lieu of products of the manufacturer noted as "basis of design", be responsible for ensuring that the substituted material or equipment is equivalent in
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size, performance and operating characteristics to the specified materials or equipment, and it shall be understood that all costs for larger starters, additional space, larger power feeders, and changes to associated or adjacent work required as a result of providing materials and equipment named as acceptable in lieu of the specified product will be borne by the Contractor.

- 1.19.17 In addition to the manufacturers specified or named as acceptable, the Contractor may propose substitute manufacturers of equipment and/or apparatus to the Consultant for acceptance, listing in each case a corresponding credit for each substitute proposed, however, the tender price must be based on apparatus or materials specified or named as acceptable. Certify in writing to the Consultant that the substitute meets all space, power, design, and all other required of the specified or equivalent material or apparatus. In addition, it shall be understood that all costs for larger starters, space, power feeders, and changes to associated equipment, mechanical and/or electrical, required by acceptance of proposed substitutions, will be borne by the party making the proposal. Substitute equipment requiring greater than specified energy requirements or unduly limiting service space requirements will not be accepted.
- 1.19.18 Where a manufacturer is not listed for a particular product, it will be deemed to mean that the Contractor will provide the specified manufacturer's product.

1.20 EXAMINATION AND PREPARATION

- 1.20.1 Refer to Division 01.
- 1.20.2 Examine the existing equipment, the site and surrounding areas and be fully informed as to the conditions and limitations under which the work has to be executed. Claims for additional costs will not be entertained with respect to conditions which could reasonably have been ascertained by an inspection prior to Tender closing.
- 1.20.3 Examine work upon which your work depends. Report in writing defects in such work. Application of your work shall be deemed acceptance of work upon which your work depends.
- 1.20.4 Drawings are, in part, diagrammatic and are intended to convey scope of work and indicate general and approximate location, arrangement and sizes of equipment, piping, and similar items. Obtain more accurate information about locations, arrangement and sizes from study and coordination of drawings, including shop drawings and manufacturers' literature and become familiar with conditions and spaces affecting these matters before proceeding with work.
- 1.20.5 Where job conditions require reasonable changes in indicated locations and arrangements, make such changes with approval of the Consultant at no additional cost to the Owner. Similarly, where existing conditions interfere with new installation and require relocation, such relocation is included in work.

1.21 CUTTING AND PATCHING

- 1.21.1 Refer to Section 01 73 29.
- 1.21.2 The Electrical Contractor will be responsible for all cutting and patching required for the electrical installation. Structural members are not to be cut without the consent of the Consultant.
- 1.21.3 All cutting and patching required under Division 26, Division 27, and Division 28 shall be in accordance with Division 01. Layout such work for approval before undertaking same.
- 1.21.4 Cutting shall be kept to an absolute minimum and performed in a neat and workmanlike manner using the proper tools and equipment. Caution shall be exercised in all cutting and procedures to ensure that concealed services are not affected. Do not cut if in doubt. Request the Consultant's presence to determine if concealed services exist.
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- 1.21.5 Assume responsibility for prompt installation of Work in advance of concrete pouring or similar Work. Should any cutting or repairing of finished/unfinished Work be required because such installation was not done, employ the particular trade, whose Work is involved, to do such cutting and patching. Pay for any resulting costs. Layout such Work for approval before undertaking same.

1.22 CLEANING AND WASTE MANAGEMENT

- 1.22.1 Refer to Section 01 74 19.
- 1.22.2 The Contractor and associated sub trades, at all times during construction, to keep the site free of all debris, boxes, packing, etc., resulting from work of this trade. At the completion of this work, the electrical installation is to be left in a clean and finished condition to the satisfaction of the Consultant.
- 1.22.3 Clean and repair existing materials and equipment which remain or are to be reused.
- 1.22.4 Luminaires to be reinstalled: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.
- 1.22.5 Assume responsibility for removing tools and waste materials on completion of Work, and leave Work in clean and perfect condition.

1.23 STARTING AND ADJUSTING

- 1.23.1 Refer to Division 01.
- 1.23.2 Conduct acceptance tests to demonstrate that the equipment and systems actually meet the specified requirements. Tests may be conducted as soon as conditions permit, and consequently make all changes, adjustments, or replacements required as the preliminary tests may indicate prior to the final tests. Tests shall be as specified in various sections of this Division. Carry out tests in the presence of the Consultant. Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project. The Electrical Contractor shall be in charge of the plant during tests. He shall assume responsibility for damages in the event of injury to the personnel, building, equipment, and shall bear all costs for liability, repairs, and restoration in this connection. Submit test results.
- 1.23.3 Make tests of equipment and wiring at times requested.
- 1.23.4 Tests shall include meggered insulation values, voltage and current readings to determine balance of panels and feeders under full load, and operation of each piece of equipment for correct operation.
- 1.23.5 Supply meters, materials and personnel as required to carry out these tests.
- 1.23.6 Test electrical work to standards and function of Specification and applicable codes in an approved manner. Replace defective equipment and wiring with new material and leave entire system in complete first class operating condition.
- 1.23.7 Connect single phase loads so that there is the least possible unbalance of the supply phases.
- 1.23.8 Submit all test results in report format.
- 1.23.9 Trial Usage
 - 1.23.9.1 The Consultant reserves the right to use any system, piece of equipment, device, or material for such reasonable lengths of time and at such times as may be required to make a complete and thorough test of the same, or for the purpose of learning operational procedures, before the final completion and acceptance of the work. Such tests shall not be construed as evidence of acceptance of the work, and it is agreed and understood that no claim for damage will be made for injury or breakage to any part or parts of the above due to the aforementioned tests, where such injuries or breakage are caused

by a weakness or inaccuracy of parts, or by defective materials or workmanship of any kind. Supply all labour and equipment required for such tests.

- 1.23.9.2 Perform and pay for all costs associated with any testing required on the system components where, in the opinion of the Consultant the equipment manufacturer's ratings or specified performance is not being achieved.

1.24 CLOSEOUT PROCEDURES

- 1.24.1 Refer to Section 01 77 00.
- 1.24.2 The Consultant will carry out inspections and prepare deficiency list for action by the Contractor, during and on completion of project.
- 1.24.3 Building Permit Compliance
- 1.24.3.1 Provide a minimum of 10 business days notice to the Consultant for scheduling of Consultant's occupancy inspection.
- 1.24.3.2 Prior to requesting the Consultant's letter "Review of General Conformance" for submission to the municipal building department to allow occupancy, the following items must be complete and submitted to the Consultant, as applicable:
- (1) General
 - (A) Submit all applicable inspection reports from Authorities Having Jurisdiction.
 - (B) Continuity of fire separations at service penetrations must be complete.
 - (C) All seismic restraint requirements as described in Section 26 05 48.16 must be complete.
 - (2) Electrical
 - (A) Provide Certificate of Acceptance from Electrical Inspection Department.
 - (B) Any devices not installed must have the wiring made safe and terminated in an outlet box complete with cover.
 - (C) All outlets must have cover plates installed. All electrical equipment not located in service rooms must have covers and/or doors installed complete.
 - (D) Emergency lighting system must be operational and tested by the Contractor. Where battery units and remote heads are indicated on the drawing, provide certification letter from equipment manufacturer indicating the system meets code requirements.
 - (E) If the building is provided with emergency power with CSA C282 equipment (emergency generator or similar), the contractor is to perform light meter measurements and submit a letter indicating the system meets code requirements.
 - (F) Simulate normal power failure within the premises in the presence of the consultant and the owner's representative. Test and verify exit lights and emergency lighting operations under emergency conditions. Submit letter of certification copy to the Consultant stating that the systems have been tested, witnessed by the Consultant or the Owner's representative, etc., and the methods of installation and performance are satisfactory to all parties.
 - (G) All exit lights must be installed and operational.
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(3) Electronic Safety and Security

- (A) Fire alarm system and devices must be operational. Submit fire alarm verification report per CAN/ULC-S537, and submit audibility test. Indicate tap settings of all signalling devices.
- (B) Functional testing of the fire alarm system and interconnected systems per CAN/ULC-S1001 must be completed.

1.24.3.3 If any of the above items have not been completed at the time of Consultant's Inspection, and the letter of "assurance of professional field review and compliance" cannot be issued, any costs for subsequent Inspections will be charged to the Contractor.

1.25 CLOSEOUT SUBMITTALS

1.25.1 Refer to Section 01 77 00.

1.25.2 Project Record Documents

1.25.2.1 Provide extra sets of white prints on which to make, as the job progresses, all approved changes and deviations from the original drawings. Complete as-built drawings accurately marked up in red ink must be submitted for review by the Consultant before the contract is considered to be completed.

1.25.2.2 Changes and deviations include those made by addenda, change orders, and supplemental instructions, and changes and deviations to be marked on the white print record drawings indicated on supplemental drawings issued with addenda, change orders, and supplemental instructions. Maintain the "as-built" white prints at the site for periodic inspection by the Consultant throughout the duration of the work.

1.25.2.3 Upon substantial completion of the work, obtain a set of reproducible white prints of the drawings and neatly amend the print in accordance with the marked-up white prints to produce a true "as-built" set of drawings.

1.25.2.4 As-built drawings are to indicate all circuiting as installed and all distribution junction box locations as well as conduit routes.

1.25.2.5 As-Built Revit drawings

- (1) Request BIM release form from the Consultant, and submit completed form back to the Consultant.
- (2) Transfer the information from the "as-built" white prints to the files, and submit to the Consultant for review.
- (3) Employ a competent computer draftsperson to indicate changes on the electronic set of as-built drawings. Provide drawings in PDF and AutoCAD formats.
- (4) Submit three (3) USB flash drives including as-built drawings in AutoCAD format, one with each O&M manual.
- (5) Provide three (3) sets of full size as-built drawings in hard copy format, one with each O&M manual.

1.25.2.6 As-built Single Line Diagram

- (1) Provide in Main Electrical Room one wall mounted copy of as-built Single Line Diagram on 6 mm (1/4 in) foam board.
- (2) As-built Single Line Diagram to indicate manufacturer name and catalogue numbers of as-installed products.

1.25.3 Operations and Maintenance (O&M) Data

- 1.25.3.1 Submit two complete sets of Operation and Maintenance instruction manuals in hard copy, and one in electronic format. Include in each copy of the manual:
 - (1) Verification certificates for installation of life safety systems by the manufacturer's representative.
 - (2) A copy of "reviewed" shop drawings.
 - (3) Complete explanation of operating principles and sequences.
 - (4) Recommended maintenance practices and precautions.
 - (5) Complete wiring and connection diagrams.
 - (6) Certificates of guarantees.
- 1.25.3.2 Ensure that operating and maintenance instructions are specific and apply to the model and types of equipment provided.
- 1.25.3.3 Include attendance records for each training session in the O&M manual.
- 1.25.4 Warranties
 - 1.25.4.1 Submit a written guarantee to the Owner for one year from the date of acceptance. This guarantee shall bind the contractor to correct, replace or repair promptly any defective equipment workmanship without cost to the Owner.
 - 1.25.4.2 All equipment, materials and workmanship shall be unconditionally guaranteed for a minimum period of one year from the date of acceptance.
 - 1.25.4.3 Provide warranty certificates, wherever given or required, in excess of the normal warranty period showing the name of the firm giving the warranty, dated and acknowledged, on specific equipment and systems.
 - 1.25.4.4 Warranties for temperature controls and building automation systems will start on the date of verification of acceptance by the Consultant.
 - 1.25.4.5 Include these certificates with the maintenance and operating manuals in the appropriate sections.

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 CONCRETE WORK

- 3.1.1 Refer to Division 03 – Concrete, and Section 26 05 29.
- 3.1.2 Provide all concrete work required for the electrical work. Reinstall surfacing as per architectural requirements.
- 3.1.3 Provide a 100 mm (4 in) high concrete housekeeping pad for floor mounted electrical distribution equipment, such as the following:
 - 3.1.3.1 Transformers.
 - 3.1.3.2 Switchgear and switchboards.
 - 3.1.3.3 Distribution panelboards.
 - 3.1.3.4 Engine Generators.
 - 3.1.3.5 Uninterruptible Power Supplies and batteries.
 - 3.1.3.6 Transfer Switches.

3.2 LINTELS

- 3.2.1 Refer to Division 04 – Masonry.
 - 3.2.2 Lintels for openings in masonry shall conform with requirements of by-laws, and as approved by the Structural Engineer.
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- 3.2.3 Pay all costs for lintels over openings, required solely by the electrical trades, not shown on architectural or structural drawings.

3.3 METALS

- 3.3.1 Refer to Division 05 – Metals.
- 3.3.2 Steel construction required solely for the work of this trade, and not shown on architectural or structural drawings shall be provided by this Division to the requirements of Division 05.

3.4 FLASHING AND SHEET METAL

- 3.4.1 Refer to Section 07 62 00.
- 3.4.2 Flash all conduits and systems passing through roof or built into an outside wall, or a waterproof floor.
- 3.4.3 Provide copper flashing for sleeves passing through exterior walls or waterproof floors.

3.5 FIRESTOPPING

- 3.5.1 Provide firestopping in accordance with Section 07 84 00 and Section 26 05 44.13.
- 3.5.2 Ensure that fire ratings of floors and walls are maintained.
- 3.5.3 Provide ULC classified firestopping products by 3M, Hilti, STI, or approved equal which have been tested in accordance with CAN/ULC-S115.
- 3.5.4 Pack clearance spaces, fill all spaces between openings, pipes and ducts passing through fire separations and install firestopping systems in accordance with the appropriate ULC system number for the products and type of penetration.
- 3.5.5 Install firestopping systems using personnel trained or instructed by the product manufacturer.

3.6 ACCESS DOORS

- 3.6.1 Provide access doors in accordance with Section 08 31 00.
- 3.6.2 Before commencing installation of work, coordinate with other trades and prepare on a set of reflected ceiling plans and wall elevations, complete layouts of access doors. Submit these layouts for Consultant's review and show exact sizes and locations of such access doors. Locate and arrange the work to suit.
- 3.6.3 Group conduit work to ensure the minimum number of access doors is required.
- 3.6.4 Access doors are to be installed by the trade responsible for the particular type of construction in which the doors are required.

3.7 PAINTING AND FINISHES

- 3.7.1 Refer to Section 09 91 00.
 - 3.7.2 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.
 - 3.7.3 Repair and finish factory finished equipment, damaged, or scratched during installation, in an approved manner.
 - 3.7.4 All structural steel including hangers, brackets, supports and other ferrous metals shall be shop or factory prime painted wherever practicable. Wherever structural steel including hangers, brackets, supports, and other ferrous metals cannot be shop or factory prime painted, wire brush to remove all traces of rust, clean of all traces of dirt, oil, and grease, and apply one coat of an approved rust inhibiting primer in accordance with CGSB-GB-40d, and leave ready to receive finish paint.
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- 3.7.5 Primary and final painting for Work, other than items specified as factory primed or finished, will be performed as described in Division 09 – Finishes.
- 3.7.6 All electrical fittings, supports, hanger rods, pull boxes, channel frames, conduit racks, outlet boxes, brackets, clamps etc., to have galvanized finish or paint finish over corrosion-resistant primer.
- 3.7.7 All panelboards, motor starters etc., to be factory finished with baked on enamel. All enamel to be baked on gloss over corrosion resistant primer.
- 3.7.8 Touch up minor damage to finish on factory finished equipment. Items suffering major damage to finish shall be replaced at the direction of the Consultant.
- 3.7.9 Protect work so that finishes will not be damaged or marred during construction. Maintain the necessary protection until completion of the work.
- 3.7.10 Provide all exposed ferrous metal work on equipment with at least one factory prime coat, or paint one prime coat on job. Clean up or wire brush all equipment, etc., before painting.
- 3.7.11 For factory applied finishes, repaint or refinish surfaces damaged during shipment, erection or construction work.

3.8 LOCATION OF OUTLETS

- 3.8.1 Refer to Architectural drawings for dimensions denoting exact locations.
- 3.8.2 The Consultant reserves the right to change the location of outlets to within 3 m from the point indicated on the plans without extra charge providing the Contractor is advised before installation is made.
- 3.8.3 Location of lighting, convenience, telephone, power, and communication outlets shall be subject to change, without extra cost to Owners, provided information is given prior to installation. No extra amount will be paid for extra labour and materials for relocating outlets up to 3000 mm from their original location nor will credits be anticipated where relocation up to 3000 mm reduces materials and labour. Other cases will be considered on their individual merits.
- 3.8.4 Coordinate location of boxes with latest architectural drawings and instructions to suit door swings, millwork etc. prior to rough-in.

3.9 MOUNTING HEIGHTS AND DEVICE LOCATIONS

- 3.9.1 Refer to architectural drawings for exact location of electrical equipment and devices.
- 3.9.2 Architectural elevations take precedence over electrical elevations. If there are conflicts between architectural and electrical, adjust locations of electrical equipment at no additional cost to the owner.
- 3.9.3 Prior to roughing-in, the contractor is to mark locations of electrical equipment and devices for conflicts with architectural, studs, etc. If conflicts are noted, inform the Consultant for a decision prior to commencing the rough-in.
- 3.9.4 Mounting heights of equipment and devices listed below is from finished floor to centreline of equipment, unless specified or indicated otherwise.
- 3.9.5 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.
- 3.9.6 Install electrical equipment at following heights above finished floor (AFF). Dimensions are to centre of device unless indicated otherwise.
 - 3.9.6.1 Power door operator push buttons: 1000 mm.
 - 3.9.6.2 HVAC thermostats and manual HVAC controls: 1200 mm.
 - 3.9.6.3 Local switches, and manual lighting control devices:
 - (1) 1100 mm.

- (2) Locate on lock side of door.
- 3.9.6.4 System furniture service fittings: to suit furniture layout.
- 3.9.6.5 Wall receptacles:
 - 1.1.1.1.1 General: min. 400 mm AFF.
 - (1) Above top of counters: 175 mm.
 - (2) Above top of continuous baseboard heater, or mechanical heating/radiation units: 75 mm to bottom of device.
 - (3) In fan rooms, mechanical rooms, and electrical rooms: 1100 mm.
 - (4) For electric ranges: 130 mm.
- 3.9.6.6 Outlets in raceways or millwork to be located as per Architectural details.
- 3.9.6.7 Door bell pushbuttons: 1100 mm.
- 3.9.6.8 Panelboards: as indicated in Section 26 24 16.
- 3.9.6.9 Emergency lighting remote heads: 300 mm below finished ceiling, or 2400 mm AFF for exposed areas or areas with ceiling height above 2750 mm (9 ft).
- 3.9.6.10 Communications:
 - (1) Typical communication outlets (voice and data): 400 mm.
 - (2) Communications outlets for wall mounted telephones, intercom, or similar: 1100 mm.
 - (3) Television outlets: 200 mm below finished ceiling.
 - (4) Wall mounted public address speakers: 2100 mm.
 - (5) Clocks: 2100 mm.
- 3.9.6.11 Access control card readers and keypads: 900 mm.
- 3.9.6.12 Fire alarm manual pull stations: 1200 mm.
- 3.9.6.13 Wall mounted fire alarm audible devices, including bells or horns:
 - (1) 2300 mm to the top of the device in areas of ceiling height 2450 mm or greater.
 - (2) 150 mm below the finished ceiling for ceiling heights less than 2450 mm, measured to the top of the device.
- 3.9.6.14 Wall mounted fire alarm visible signal devices, including strobes: 2300 mm.
- 3.9.6.15 Fire Alarm emergency telephones: 1400 mm.

3.10 MANUFACTURER'S INSTRUCTIONS

- 3.10.1 Where the specifications call for an installation to be made in accordance with Manufacturer's recommendations, a copy of such recommendations shall be at all times be kept on the job site and be available to the Owner's Representative.
- 3.10.2 Follow manufacturer's instructions where they cover points now specifically indicated on the drawings and specifications. If they are in conflict with the drawings and specifications obtain clarification from the Consultant before starting work.

3.11 TESTS AND ACCEPTANCE

- 3.11.1 The operation of the equipment and electrical system does not constitute an acceptance of the work by the Owner. The final acceptance is to be made after the Contractor has adjusted his equipment and demonstrated that it fulfills the requirements of the drawings and the specifications.
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- 3.11.2 Testing of all systems shall be performed in the presence of the Owner's designated representative. The contractor shall give 72 hours advance notice to the Owner before beginning the tests.
- 3.11.3 Upon completion of the installation, the Contractor shall furnish certificates of approval from all authorities having jurisdiction, as applicable. Contractor shall demonstrate that work is complete and in perfect operating condition, with raceway and conduit systems properly grounded, wiring free from grounds, shorts, and that the entire installation is free from any physical defects.
- 3.11.4 Provide labour and material to conduct the integrated systems testing of interconnected life safety systems in accordance with CAN/ULC-S1001-11.

3.12 CLOSEOUT ACTIVITIES

- 3.12.1 Refer to Section 01 77 00.
- 3.12.2 In the presence of the Owner, demonstrate the proper operation of all systems.
- 3.12.3 Instruct the Owner's designated representatives in all aspects of the operation and maintenance of systems and equipment listed in the trade sections governed by this Section. Obtain in writing from the Consultant a list of the Owner's representatives qualified to receive instructions.
- 3.12.4 Arrange for and pay for the services of qualified service technicians and other manufacturer's representatives required for instruction of specialized portions of the installation.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Building wire and cable.
 - 1.1.1.1 Armoured cable.
 - 1.1.1.2 Metal clad cable.
 - 1.1.1.3 Fire resistive cables.
 - 1.1.1.4 Wiring connectors and connections.
- 1.1.2 Permitted voltage drop for feeder and branch circuits.

1.2 REFERENCES

- 1.2.1 CSA Group:
 - 1.2.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.2.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.2.1.3 CSA C22.2 No. 0.3-09 (R2019), Test methods for electrical wires and cables.
 - 1.2.1.4 CSA C22.2 No. 48-15, Nonmetallic sheathed cable.
 - 1.2.1.5 CSA C22.2 No. 51-14, Armoured cables.
 - 1.2.1.6 CSA C22.2 No. 52-15, Underground secondary and service-entrance cables.
 - 1.2.1.7 CSA C22.2 No. 65-13, Wire connectors.
 - 1.2.1.8 CSA C22.2 No. 75-17, Thermoplastic insulated wires and cables.
 - 1.2.1.9 CSA C22.2 No. 123-16, Aluminum sheathed cables.
 - 1.2.1.10 CSA C22.2 No. 131-14, Type TECK 90 cable.
- 1.2.2 NECA (National Electrical Contractors Association) - Standard of Installation.
- 1.2.3 NETA (International Electrical Testing Association) - ATS-2021 - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
- 1.2.4 CAN/ULC-S139:2017 – Standard Method of Fire Test for Evaluation of Integrity of Electrical Power, Data and Optical Fibre Cables.

1.3 COORDINATION

- 1.3.1 Where wire and cable destination is indicated, and routing is not shown, determine exact routing and lengths required.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Record Documents: Indicate as-constructed feeder sizes on single line diagram.
- 1.4.2 Megger test results.
- 1.4.3 Thermographic survey report.
- 1.4.4 Fire rated cables: manufacturer's certification that the cables have been installed in accordance with the manufacturer's instructions.

1.5 QUALIFICATIONS

- 1.5.1 Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 American Wire Group.
 - 2.1.2 BICC Phillips.
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- 2.1.3 General Cable.
- 2.1.4 Nexans.
- 2.1.5 Prysmian.
- 2.1.6 Southwire.

2.2 REGULATORY REQUIREMENTS

- 2.2.1 Provide products listed and classified by CSA Group as suitable for the purpose specified and indicated.

2.3 CONDUCTOR MATERIAL

- 2.3.1 Submit bid based on copper conductors only.
- 2.3.2 Aluminum: Not permitted.

2.4 BUILDING WIRE

- 2.4.1 RW90:
 - 2.4.1.1 Single copper conductor.
 - 2.4.1.2 Minimum 12 AWG for branch circuit wiring.
 - 2.4.1.3 Minimum 14 AWG for 120 V control wiring.
 - 2.4.1.4 Chemically cross-linked polyethylene insulation.
 - 2.4.1.5 Rated for 90°C, 600 V.
 - 2.4.1.6 Suitable for handling to minus 40°C.
 - 2.4.1.7 For interior installations in conduit.
- 2.4.2 RWU90:
 - 2.4.2.1 Single copper conductor.
 - 2.4.2.2 Minimum 12 AWG for branch circuit wiring.
 - 2.4.2.3 Minimum 14 AWG for 120 V control wiring.
 - 2.4.2.4 Chemically cross-linked polyethylene insulation.
 - 2.4.2.5 Rated for 90°C, 1000 V.
 - 2.4.2.6 Suitable for handling to -40°C.
 - 2.4.2.7 For exterior installations in conduit.
- 2.4.3 T90 Nylon:
 - 2.4.3.1 Single copper conductor.
 - 2.4.3.2 Thin wall PVC insulation with nylon covering.
 - 2.4.3.3 Rated for 90°C, 600 V.
 - 2.4.3.4 May be used up to size 10 AWG for interior installations.
 - 2.4.3.5 Base conduit fill on RW90 cable diameters.

2.5 ARMoured CABLE

- 2.5.1 General
 - 2.5.1.1 Connectors: standard as required, complete with anti-short rings.
 - 2.5.1.2 Runs to be limited to fixture drops, and runs to devices in walls and partitions, maximum horizontal runs in exposed areas and ceiling spaces to be 1.8 m (6 ft).
 - 2.5.1.3 Do not daisy chain (leap frog) luminaires with armoured cable.
 - 2.5.2 Type AC:
 - 2.5.2.1 Two, three or four copper conductors rated RW90, 1000 V.
 - 2.5.2.2 Bare copper ground wire.
 - 2.5.2.3 Insulation Voltage Rating: 600 V.
 - 2.5.2.4 Insulation Temperature Rating: 90°C (194°F).
 - 2.5.2.5 Insulation Material: Thermoplastic.
 - 2.5.2.6 Overall interlocked aluminum tape armour.
-

- 2.5.3 Type SPC90:
 - 2.5.3.1 Use for LED lighting, fluorescent dimming controls, and other SMART building applications.
 - 2.5.3.2 Colour coded cable with power, control, and signal under one cable.
 - 2.5.3.3 12-2C Power with a 16-2C Control.
 - 2.5.3.4 Bare copper ground wire.
 - 2.5.3.5 Insulation Voltage Rating: 600 V.
 - 2.5.3.6 Insulation Temperature Rating: 90°C (194°F).
 - 2.5.3.7 Insulation Material: Thermoplastic.

2.6 FIRE RESISTIVE CABLES

- 2.6.1 General:
 - 2.6.1.1 2 hour fire rating to CAN/ULC-S139 and to meet 2012 Ontario Building Code rule 3.2.7.10.
 - 2.6.1.2 Alternative means of compliance:
 - (1) Conduits encased in a minimum of 50 mm (2 in) of concrete.
 - (2) Be protected by a fire rated assembly listed to achieve the minimum fire rating as indicated.
- 2.6.2 Manufacturers:
 - 2.6.2.1 nVent Pyrotenax 1850 series Mineral Insulated (MI) cable.
 - 2.6.2.2 VITALink MC Brand Type MC-RC90, manufactured by Marmon Wire & Cable Inc. (listed by ULC under ULC category code 'FHIT7' or 'FHJR7', dated 19 May 2015). This cable is not to be installed in conduit.
 - (1) Request quotation from manufacturer or manufacturer's representative for field certification of installed Vitalink cables prior to requesting Consultant's construction field review.
 - (2) Power cable must be installed according to UL protocol FHIT7.120 – Electrical circuit integrity systems certified in Canada.
 - 2.6.2.3 Prysmian Lifeline RC90 cable.
 - (1) Installation in accordance with UL protocol FHIT7-51, and FHIT7-51A.
 - (2) System makes use of Remke connectors and Resolve boxes, with no substitutions.
- 2.6.3 Substitution Limitations:
 - 2.6.3.1 Substitutions may only be considered by the Consultant if the product is listed by ULC under ULC Category Codes 'FHIT7' or 'FHJR7'.

2.7 TECK90 CABLE

- 2.7.1 Single, three, or four conductors as indicated on drawings.
- 2.7.2 Cable to CSA C22.2 No. 131.
- 2.7.3 Conductors:
 - 2.7.3.1 Grounding conductor: copper.
 - 2.7.3.2 Circuit conductors: copper, size as indicated.
- 2.7.4 Insulation: Cross-linked polyethylene (XLPE), type RW90, rating: 600 V.
- 2.7.5 Inner jacket: polyvinyl chloride.
- 2.7.6 Armour: interlocking aluminum.
- 2.7.7 Overall covering: thermoplastic.
- 2.7.8 Fastenings:
 - 2.7.8.1 One-hole steel straps to secure surface cables 50 mm diameter and smaller.
Two-hole steel straps for cables larger than 50 mm diameter.

2.7.8.2 Channel type supports for two or more cables at 1500 mm centres.

2.7.8.3 Threaded rods: 6 mm diameter to support suspended channels.

2.7.9 Connectors: Watertight, approved for TECK cable.

2.8 CONDUCTOR PULLING LUBRICANT

2.8.1 Where pulling lubricant is required, use non-wax based cable lubricants compatible with cable manufacturer recommendations, such as American Polywater.

2.9 CONNECTORS

2.9.1 Armoured cable connectors must be proper squeeze type connectors and plastic anti-short bushings at terminations.

2.9.2 Connectors for conductors connecting to devices as per local governing electrical requirements to be equal to IDI Electric (Canada) Ltd., "Ideal" No. 451, No. 452, and No. 453, "Wing-Nut", CSA certified, 600 V, rated pressure type connectors.

2.9.3 For conductors sized 3/0 AWG and greater, provide long barrel double crimp, two (2) hole compression type lug connectors, unless otherwise noted.

2.10 WIRING TERMINATION

2.10.1 Lugs, terminals, or screws used for termination of wiring to be suitable for copper conductors. Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring. Maintain phase sequence and colour coding throughout.

2.10.2 Splice wire, up to and including 6 AWG, with nylon insulated expandable spring type connectors.

2.10.2.1 Thomas & Betts – Marr Max series.

2.10.3 Splice large conductors using compression type connections insulated with heat shrink sleeves.

2.10.3.1 Thomas & Betts – 5400 Series lugs & heat shrink type #s series.

3 EXECUTION

3.1 EXAMINATION

3.1.1 Verify that field measurements are as indicated.

3.1.2 Wire and cable routing indicated is approximate unless dimensioned.

3.1.3 Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.

3.1.4 Voltage Drop

3.1.4.1 Ensure voltage drop in power and control conductors is in accordance with the requirements of the OESC.

3.1.4.2 Size conductors accordingly when sizes are not identified.

(1) Feeder conductors: maximum voltage drop of 2%.

(2) Branch circuit conductors: maximum voltage drop of 3%.

3.1.5 Verify that mechanical work likely to damage wire and cable has been completed.

3.1.6 Verify that raceway installation is complete and supported.

3.2 PREPARATION

3.2.1 Completely and thoroughly swab raceway before installing wire.

3.3 INSTALLATION

- 3.3.1 Route wire and cable as required to meet project conditions.
- 3.3.2 Install cable to CSA C22.1 and per manufacturer's installation guidelines.
- 3.3.3 Conduit and cable supports:
 - 3.3.3.1 All wiring to be installed in EMT at all exposed areas unless otherwise specified.
 - 3.3.3.2 All mechanical equipment to be connected with liquid tight flexible conduit.
 - 3.3.3.3 Support cables above accessible ceiling, using spring metal clips to support cables from structure. Do not rest cable on ceiling panels.
- 3.3.4 Conductors
 - 3.3.4.1 Provide separate neutral for each circuit. Common neutrals not permitted.
 - 3.3.4.2 Use solid conductor for feeders and branch circuits 10 AWG and smaller.
 - 3.3.4.3 Use stranded conductors for control circuits.
 - 3.3.4.4 Use conductor not smaller than 12 AWG for power and lighting circuits.
 - 3.3.4.5 Use conductor not smaller than 16 AWG for control circuits.
 - 3.3.4.6 Use 10 AWG conductors for 20 A, 120 volt branch circuits longer than 25 m.
- 3.3.5 Pulling conductors
 - 3.3.5.1 Pull all conductors into raceway at same time.
 - 3.3.5.2 Use suitable wire pulling lubricant for building wire 4 AWG and larger.
 - 3.3.5.3 Neatly train and lace wiring inside boxes, equipment, and panelboards.
 - 3.3.5.4 Protect exposed cable from damage.
- 3.3.6 Connectors
 - 3.3.6.1 Use suitable cable fittings and connectors.
 - 3.3.6.2 Clean conductor surfaces before installing lugs and connectors.
 - 3.3.6.3 Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
 - 3.3.6.4 Use split bolt connectors for copper conductor splices and taps 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 per cent of insulation rating of conductor.
 - 3.3.6.5 Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
 - 3.3.6.6 Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.
- 3.3.7 Identification
 - 3.3.7.1 Identify and colour code wire and cable to Section 26 05 53. Identify each conductor with its circuit number or other designation indicated.
 - 3.3.7.2 Where colour-coded tape is utilized, apply a minimum of 50 mm (2 inches) at terminations, junction and pull boxes and conduit fittings. Do not paint conductors under any condition.
 - 3.3.7.3 Utilize colour coding on bussing in panels and, switchgear, disconnects, and metering cabinets to match conductor colour coding.

3.4 CONDUCTORS, WIRES, AND CABLES

- 3.4.1 Provide fire rated conductors or provide a fire rated assembly around conductors used for life safety applications as described in 2012 OBC 3.2.7.10.
 - 3.4.2 Indoor wiring installed in conduit, unless otherwise noted: 600 V "RW90 XLPE".
 - 3.4.3 Wiring in channel back of fluorescent and LED lighting fixtures: 600 V type GTF or TEW.
 - 3.4.4 Lighting and power branch circuit wiring:
 - 3.4.4.1 Copper, minimum 12 AWG.
 - 3.4.4.2 Home runs to lighting and receptacle panels, which exceed 22 m (75 ft) in length: minimum 10 AWG.
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- 3.4.5 Size wires for 2 per cent maximum voltage drop to farthest outlet on a maximum 80% loaded circuit.
- 3.4.6 Outdoor wiring: "RWU90 XLPE".
- 3.4.7 Conductors shall be colour coded. Conductors 10 AWG and smaller shall have colour impregnated into insulation at time of manufacture. Conductors size 8 AWG and larger may be colour coded with adhesive colour coding tape, but only black insulated conductors shall be employed in this case, except for neutrals which shall be white wherever possible.
- 3.4.8 Colour coding as follows:
 - 3.4.8.1 Phase "A" – Red.
 - 3.4.8.2 Phase "B" – Black.
 - 3.4.8.3 Phase "C" – Blue.
 - 3.4.8.4 Control – Orange.
 - 3.4.8.5 Ground – Green.
 - 3.4.8.6 Neutral – White.
- 3.4.9 Neatly train circuit wiring in cabinets, panels, pull boxes and junction boxes and hold with nylon cable ties.

3.5 SITE TESTS AND INSPECTIONS

- 3.5.1 Perform continuity tests of all feeders, motor circuits, and branch circuits.
- 3.5.2 Perform infrared thermographic survey in accordance with NETA ATS, Section 9 "Thermographic Survey". Submit report to the Consultant.
- 3.5.3 Perform insulation-resistance test (megger test) on each feeder. Submit report to the Consultant.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Low-voltage control cabling.
- 1.1.2 Control-circuit conductors.

1.2 REFERENCES

- 1.2.1 CSA Group:
 - 1.2.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.2.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.2.1.3 CSA C22.2 No. 0.3-09 (R2019), Test methods for electrical wires and cables.
 - 1.2.1.4 CSA C22.2 No. 48-15, Nonmetallic sheathed cable.
 - 1.2.1.5 CSA C22.2 No. 51-14, Armoured cables.
 - 1.2.1.6 CSA C22.2 No. 65-13, Wire connectors.
 - 1.2.1.7 CSA C22.2 No. 75-17, Thermoplastic insulated wires and cables.
 - 1.2.1.8 CSA C22.2 No. 208-14, Fire alarm and signal cable.
- 1.2.2 NECA (National Electrical Contractors Association) - Standard of Installation.

1.3 QUALIFICATIONS

- 1.3.1 Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years' experience.

1.4 COORDINATION

- 1.4.1 Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.

2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

- 2.1.1 Conform to CSA C22.1.
- 2.1.2 Provide products listed and classified by CSA Group as suitable for the purpose specified and indicated.

2.2 LOW VOLTAGE WIRING

- 2.2.1 LVT:
 - 2.2.1.1 Multi conductor PVC insulated.
 - 2.2.1.2 Bare copper ground conductor.
 - 2.2.1.3 Overall PVC jacket.
 - 2.2.1.4 Rated 30 V.
 - 2.2.1.5 CMP (FT6) rated if cable is exposed.
 - 2.2.1.6 CMR (FT4) rated if cable is installed in conduit.
- 2.2.2 Category 5e Network Cabling.
 - 2.2.2.1 CMP (FT6) rated if cable is exposed.
 - 2.2.2.2 CMR (FT4) rated if cable is installed in conduit.

2.3 TERMINATIONS AND SPLICES

- 2.3.1 All terminations and splices shall be of an approved type for the conductors being used.
 - 2.3.2 Where conductors are terminated or spliced, it shall be done in the following manner:
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- 2.3.2.1 Where a single solid conductor is terminated in a device under one screw or clamping mechanism, no additional terminating hardware is required.
- 2.3.2.2 Where multiple or stranded conductors are terminated in a device under one screw or clamping mechanism, self insulated crimp-on cable ends or approved equal shall be used up to and including No. 10 AWG sized conductors. Approved compression lugs shall be used for larger conductor sizes.
- 2.3.2.3 Where multiple conductors are spliced, properly sized Wing Nut connectors, or approved equal, shall be used for up to two No. 8 AWG or three No. 10 AWG conductors. Pressure type sleeve cable connectors, splices, tee's, etc., shall be used for all larger size connections and terminations.
- 2.3.2.4 Insulate all bare surfaces of splices with heat shrink sleeving or equivalent.
- 2.3.2.5 Conductors connected to ground rods for service or equipment grounding or to building structural or architectural elements shall be terminated, connected, and spliced using a thermoweld process or approved non-mechanical compression type connectors.
- 2.3.3 Install all service and feeder conductors as continuous lengths without breaks, measured and cut based on site dimensions.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Verify that mechanical work likely to damage wire and cable has been completed.
- 3.1.2 Verify that raceway installation is complete and supported.
- 3.1.3 Verify that field measurements are as indicated.
- 3.1.4 Wire and cable routing indicated is approximate unless dimensioned.

3.2 PREPARATION

- 3.2.1 Completely and thoroughly swab raceway before installing wire.

3.3 INSTALLATION

- 3.3.1 Route control cabling as required to meet project conditions.
 - 3.3.2 Install cable to the CSA C22.1.
 - 3.3.3 Conduit and supports
 - 3.3.3.1 All wiring to be installed in EMT at all exposed areas and in partitions unless otherwise specified.
 - 3.3.3.2 All mechanical equipment to be connected with liquid tight flexible conduit.
 - 3.3.3.3 Support cables above accessible ceiling, using spring metal clips to support cables from structure. Do not rest cable on ceiling panels.
 - 3.3.4 Conductors
 - 3.3.4.1 Use stranded conductors for control circuits.
 - 3.3.4.2 Use conductor not smaller than 16 AWG for control circuits.
 - 3.3.5 Pulling conductors
 - 3.3.5.1 Pull all conductors into raceway at same time.
 - 3.3.5.2 Neatly train and lace wiring inside boxes, equipment, and panelboards.
 - 3.3.5.3 Neatly train circuit wiring in cabinets, panels, pull boxes and junction boxes and hold with nylon cable ties.
 - 3.3.5.4 Protect exposed cable from damage.
 - 3.3.6 Connectors
 - 3.3.6.1 Use suitable cable fittings and connectors.
 - 3.3.6.2 Clean conductor surfaces before installing lugs and connectors.
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- 3.3.6.3 Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
- 3.3.6.4 Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.
- 3.3.7 Identification
 - 3.3.7.1 Identify and colour code wire and cable to Section 26 05 53. Identify each conductor with its circuit number or other designation indicated.
 - 3.3.7.2 Where colour coded tape is utilized, apply a minimum of 50 mm (2 in) at terminations, junction and pull boxes and conduit fittings. Do not paint conductors under any condition.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Grounding electrodes and conductors.
- 1.1.2 Equipment grounding conductors.
- 1.1.3 Bonding.
- 1.1.4 The terms “connect” and “bond” are used interchangeably in this Specification and have the same meaning.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 27 05 26 – Grounding and Bonding for Communications Systems.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 0.4-17, Bonding of electrical equipment.
 - 1.3.1.4 CSA C22.2 No. 41-13, Grounding and bonding equipment.
 - 1.3.1.5 CSA C22.2 No. 75-17, Thermoplastic insulated wires and cables.
- 1.3.2 ANSI/TIA/EIA J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
- 1.3.3 Institute of Electrical and Electronics Engineers, Inc.
 - 1.3.3.1 IEEE 81-1983 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.

1.4 ACTION SUBMITTALS

- 1.4.1 Product Data: Provide for grounding electrodes and connections.

1.5 INFORMATIONAL SUBMITTALS

- 1.5.1 Test Reports: Indicate overall resistance to ground and resistance of each electrode.
- 1.5.2 Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 Project Record Documents: Record actual locations of components and grounding electrodes.
- 1.6.2 Certificate of Compliance: Indicate approval of installation by authority having jurisdiction.

1.7 QUALIFICATIONS

- 1.7.1 Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years' experience.

1.8 REGULATORY REQUIREMENTS

- 1.8.1 Products: Listed and classified testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.
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2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 B-Line by Eaton.
- 2.1.2 Hubbell (Burndy).
- 2.1.3 Panduit.
- 2.1.4 Thomas & Betts.

2.2 PERFORMANCE CRITERIA

- 2.2.1 Grounding System Resistance: 5 ohms.
- 2.2.2 Provide all equipment grounding as required regardless of whether it has been shown on drawings or called for in this specification. Arrange grounds so that under normal operating conditions no injurious amount of current will flow in any grounding conductor.

2.3 GROUNDING AND BONDING CONDUCTORS

- 2.3.1 Electrical grounding conductors shall be CSA C22.2 No. 75 insulated stranded copper, except that sizes #10 AWG and smaller shall be solid copper. Insulation colour shall be continuous green for all equipment grounding conductors.
- 2.3.2 Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes #10 AWG and smaller shall be ASTM B1 solid bare copper wire.

2.4 ROD ELECTRODES

- 2.4.1 Material: Copper-clad steel.
- 2.4.2 Diameter: 19 mm.
- 2.4.3 Length: 3000 mm.

2.5 GROUND RODS

- 2.5.1 Copper clad steel, 19 mm (3/4 in) diameter by 3000 mm (10 ft) long, conforming to CSA C22.2 No. 41.
- 2.5.2 Quantity of rods shall be as required to obtain the specified ground resistance.

2.6 SPLICES AND TERMINATION COMPONENTS

- 2.6.1 Components shall meet or exceed CSA C22.2 No. 41, and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.7 GROUND CONNECTIONS

- 2.7.1 Below Grade: Exothermic-welded type connectors.
- 2.7.2 Above Grade:
 - 2.7.2.1 Bonding Jumpers: compression type connectors, using zinc-plated fasteners and external tooth lockwashers.
 - 2.7.2.2 Ground Busbars: Two-hole compression type lugs using tin-plated copper or copper alloy bolts and nuts.

2.8 GROUND TERMINAL BLOCKS

- 2.8.1 At any equipment mounting location (e.g. backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.
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2.9 SPLICE CASE GROUND ACCESSORIES

- 2.9.1 Splice case grounding and bonding accessories shall be supplied by the splice case manufacturer when available. Otherwise, use 6 AWG insulated ground wire with shield bonding connectors.

2.10 MECHANICAL CONNECTORS

- 2.10.1 Material: Bronze.

2.11 WIRE

- 2.11.1 Material: Stranded copper.
2.11.2 Foundation Electrodes: 2/0 AWG.
2.11.3 Grounding Electrode Conductor: Size to meet Ontario Electrical Safety Code requirements.

2.12 GROUNDING WELL COMPONENTS

- 2.12.1 Well Pipe: 200 mm by 600 mm long concrete pipe with belled end.
2.12.2 Well Cover: Cast iron with legend "GROUND" embossed on cover.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Verify that final backfill and compaction has been completed before driving rod electrodes.

3.2 INSTALLATION

- 3.2.1 General
- 3.2.1.1 Ground in accordance with the Ontario Electrical Safety Code, as shown on drawings, and as hereinafter specified.
 - 3.2.1.2 System Grounding:
 - (1) Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
 - (2) Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.
 - 3.2.1.3 Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.
 - 3.2.1.4 Ground electrical equipment and wiring in accordance with Ontario Electrical Safety Code and Local Inspection Authority's Rules and Regulations.
 - 3.2.1.5 Install grounding conductors, outside Electric Rooms and Electrical Closets in conduit and conceal where possible. Make connections to water mains, all metallic piping systems, neutral and equipment with brass, copper or bronze bolts and connectors or weld using Cadweld or Thermoweld processes.
 - 3.2.1.6 Provide grounding conductors, sized as per Code, and connect to grounding bus or water main wherever non-raceways are installed.
- 3.2.2 Provide grounding electrode conductor and connect to reinforcing steel in foundation footing. Bond steel together.
- 3.2.3 Provide bonding to meet Regulatory Requirements.
- 3.2.4 Bond together metal siding not attached to grounded structure; bond to ground.
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- 3.2.5 Install ground grid under access floors indicated.
- 3.2.6 Bond together each metallic raceway, pipe, duct, and other metal object entering space under access floors. Bond to underfloor ground grid. Use 6 AWG bare copper conductor.
- 3.2.7 Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
- 3.2.8 Ground Resistance
 - 3.2.8.1 Grounding system resistance to ground not to exceed 5 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the Owner. Final tests shall assure that this requirement is met.
 - 3.2.8.2 Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
 - 3.2.8.3 Services at power company interface points shall comply with the power company ground resistance requirements.
- 3.2.9 Ground Rod Installation
 - 3.2.9.1 Drive each rod vertically in the earth, not less than 3000 mm (10 ft) in depth.
 - 3.2.9.2 Where permanently concealed ground connections are required, make the connections by the exothermic process to form solid metal joints. Make accessible ground connections with mechanical pressure type ground connectors.
 - 3.2.9.3 Where rock prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified resistance.
- 3.2.10 Inaccessible Grounding Connections
 - 3.2.10.1 Make grounding connections, which are buried or otherwise normally inaccessible (except connections for which periodic testing access is required) by exothermic weld.
- 3.2.11 Secondary Equipment and Circuits
 - 3.2.11.1 Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
 - 3.2.11.2 Metallic Piping, Building Steel, and Supplemental Electrode(s):
 - (1) Provide a grounding electrode conductor sized per code between the service equipment ground bus and all metallic water and gas pipe systems, building steel, and supplemental or made electrodes. Jumper insulating joints in the metallic piping. All connections to electrodes shall be made with fittings that conform to CSA C22.2 No. 41.
 - (2) Provide a supplemental ground electrode and bond to the grounding electrode system.
 - 3.2.11.3 Conduit Systems:
 - (1) Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
 - (2) Non-metallic conduit systems shall contain an equipment grounding conductor, except that non-metallic feeder conduits which carry a grounded conductor from exterior transformers to interior or building-

mounted service entrance equipment need not contain an equipment grounding conductor.

- (3) Conduit containing only a grounding conductor, and which is provided for mechanical protection of the conductor, shall be bonded to that conductor at the entrance and exit from the conduit.

3.2.11.4 Feeders and Branch Circuits: Install equipment grounding conductors with all feeders and power and lighting branch circuits.

3.2.11.5 Boxes, Cabinets, Enclosures, and Panelboards:

- (1) Bond the equipment grounding conductor to each pull box, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).
- (2) Provide lugs in each box and enclosure for equipment grounding conductor termination.
- (3) Provide ground bars in panelboards, bolted to the housing, with sufficient lugs to terminate the equipment grounding conductors.

3.2.11.6 Receptacles shall not be grounded through their mounting screws. Ground with a jumper from the receptacle ground terminal to the device box ground screw and the branch circuit equipment grounding conductor.

3.2.11.7 Raised Floors: Provide bonding of all raised floor components.

3.2.12 Corrosion Inhibitors

3.2.12.1 When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.2.13 Conductive Piping

3.2.13.1 Bond all conductive piping systems, interior and exterior, to the building to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

3.3 FIELD QUALITY CONTROL

3.3.1 Perform inspections and tests listed in NETA ATS, Section 7.13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Conduit and equipment supports.
- 1.1.2 Anchors and fasteners.

1.2 REFERENCES

- 1.2.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
- 1.2.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.2.3 CECA - Canadian Electrical Contractors Association.

1.3 ACTION SUBMITTALS

- 1.3.1 Submit detail, sealed by Contractor retained structural engineer for strut channel support for stacked transformers.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Submit the following in the Operation and Maintenance Manual for products used over the course of the project:
 - 1.4.1.1 Product Data: Provide manufacturer's catalogue data for fastening systems.
 - 1.4.1.2 Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

1.5 REGULATORY REQUIREMENTS

- 1.5.1 Provide products listed and classified by Canadian Standards as suitable for purpose specified and shown.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 B-line by Eaton.
- 2.1.2 Burndy Canada Ltd. (Hubbell).
- 2.1.3 Erico Caddy.
- 2.1.4 E. Myatt & Co. Inc.
- 2.1.5 Hilti Canada.
- 2.1.6 Thomas & Betts.
- 2.1.7 Unistrut.

2.2 GENERAL

- 2.2.1 All supporting devices, strut channel, threaded rod, anchors, etc. to be used shall be of the "hot dipped" galvanized type. Electrogalvanized components will not be accepted.
- 2.2.2 Materials and Finishes: Provide adequate corrosion resistance.
- 2.2.3 Provide materials, sizes, and types of anchors, fasteners and supports to carry the loads of equipment and conduit. Consider weight of wire in conduit when selecting products.
- 2.2.4 Anchors and Fasteners:
 - 2.2.4.1 Concrete Structural Elements: Use expansion anchor and preset inserts.

- 2.2.4.2 Steel Structural Elements: Use beam clamps and welded fasteners.
- 2.2.4.3 Concrete Surfaces: Use self-drilling anchors and expansion anchors.
- 2.2.4.4 Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts and hollow wall fasteners.
- 2.2.4.5 Solid Masonry Walls: Use expansion anchors and preset inserts.
- 2.2.4.6 Sheet Metal: Use sheet metal screws.
- 2.2.4.7 Wood Elements: Use wood screws.

2.3 ANCHORS AND HANGERS

- 2.3.1 Hangers for electrical conduit shall be galvanized after fabrication.
- 2.3.2 Perforated strapping: not permitted.

2.4 INSERTS

- 2.4.1 Use only factory-made threaded or toggle type.
- 2.4.2 Where inserts cannot be placed, use factory-made expansion shields for light weights, where approved by the Consultant.
- 2.4.3 Do not use powder-activated tools except with the written permission of the Consultant.

2.5 SLEEVES

- 2.5.1 Through interior walls, use standard weight steel pipes, conduit, or 18 gauge galvanized steel. Cut flush with finished surfaces. Check room finish schedules.
- 2.5.2 Through exterior walls above grade, floors, and roof use standard weight steel pipes, machine cut, flush with finished surface inside and to suit flashing outside.
- 2.5.3 Through exterior walls below grade, water-proofed floors, and other water-proof walls, use heavy weight cast iron pipes, machine cut. Extend sleeves 100 mm (4 in) above finished floors, and cut flush with underside of floor.

2.6 STEEL CHANNEL

- 2.6.1 Description: Painted steel.

2.7 SUPPORTS

- 2.7.1 Steel supports in wet or dry locations to be galvanized after fabrication.
- 2.7.2 Where galvanized members are bolted together use cadmium plated bolts.
- 2.7.3 For hanger rods use minimum 10 mm (3/8 in) diameter steel threaded rod. Use clevis type attachment.
- 2.7.4 Provide minimum 100 mm (4 in) high concrete bases for all floor mounted equipment.

2.8 SUPPORTS AND BASES

- 2.8.1 Submit proposed method of attachment of hangers and beam clamps, to cellular steel deck for approval before proceeding with Work.
 - 2.8.2 Supply and erect special structural Work required for the installation of electrical equipment. Provide anchor bolts and other fastenings unless noted otherwise. Mount equipment required to be suspended above floor level, where details are not shown, on a frame or platform bracketed from the wall or suspended from the ceiling. Carry supports to either the ceiling or the floor, or both as required, at locations where, because wall thickness is inadequate, it is not permitted to use such brackets.
 - 2.8.3 Electrical panels, switches or other electrical equipment shall be complete with suitable bases or mounting brackets.
 - 2.8.4 Provide channel or other metal supports where necessary, to adequately support lighting fixtures. Do not use wood unless wood forms part of the building structure.
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- 2.8.5 Support hangers, in general, from inserts in concrete construction or from building structural steel beams, using beam clamps. Provide additional angle or channel steel members, required between beams for supporting conduits and cables.
- 2.8.6 Provide any additional supports required from existing concrete construction for any piping or equipment, by drilling same and installing expansion bolt cinch anchors.
- 2.8.7 Do not use explosive drive pins in any section of Work without obtaining prior approval.

2.9 STACKED TRANSFORMER SUPPORT

- 2.9.1 Stacking of transformers is only allowed if all other options have been exhausted due to lack of space. Stacking is only applicable to floor mount applications and is not allowed for ceiling or wall mount configurations. Stacking shall comply with the following requirements:
 - 2.9.1.1 The transformer stacked on top is the same size or smaller than the transformer below.
 - 2.9.1.2 The OESC clearance requirements for each individual transformer is satisfied.
 - 2.9.1.3 The ambient temperature must not exceed 30°C.
- 2.9.2 Strut channel structure to support transformers shown on Drawings to be stacked above another transformer.
- 2.9.3 Provide sheet metal heat diversion shield between stacked transformers. Install shield at an angle as not to trap heat.

2.10 CONCRETE BASES AND HOUSEKEEPING PADS

- 2.10.1 Provide concrete bases of dimensions where indicated, but not less than 100 mm (4 in) larger in both directions than supported unit, and 100 mm (4 in) high, and so anchors will be a minimum of 10 bolt diameters from edge of the base. Chamfer edges.
- 2.10.2 Use 20 MPa (3000 psi) 28 day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 – Concrete.
- 2.10.3 Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 450 mm (18 in) centres around full perimeter of base.
- 2.10.4 Anchor equipment to concrete base.
- 2.10.5 Provide a housekeeping pad for floor mounted equipment, including but not limited to the following:
 - 2.10.5.1 Transformers.
 - 2.10.5.2 Switchgear and switchboards.
 - 2.10.5.3 Distribution panelboards.
 - 2.10.5.4 Engine Generators.
 - 2.10.5.5 Uninterruptible Power Supplies and batteries.
 - 2.10.5.6 Transfer Switches.

2.11 CONCRETE ANCHORS

- 2.11.1 Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2.11.2 Drilled expansion anchors for anchors set in concrete block or poured concrete after the concrete has set. Size the insert and number of anchors so that the maximum load per anchor does not exceed the manufacturer's recommendation.
 - 2.11.3 U-channel concrete inserts shall be 12 gauge steel 1-5/8 in square with insert anchors 1 3/8 in long and 100 mm (4 in) on centre.
 - 2.11.4 Install anchor bolts to elevations required for proper attachment to supported equipment.
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2.12 PLYWOOD EQUIPMENT BOARDS

- 2.12.1 Plywood Equipment Boards: preservative treated, and kiln dried; thickness as indicated, or if not indicated, not less than 19 mm (3/4 in) deep. Provide marine grade plywood where subject to moisture conditions.
- 2.12.2 Paint plywood board white, or to match adjacent finishes. Leave the fire-retardant label unpainted for verification by the Consultant and by Authority Having Jurisdiction (AHJ).
- 2.12.3 Unless otherwise noted, boards shall be painted with two coats of good grade weatherproof flat gray non-conductive fire-retardant paint on all sides and edges (prior to mounting) and plumbed in a true vertical position. Provide nominal 13 mm (1/2 in) rustproof spacers between back of plywood and wall. Cut, fit, and place plywood equipment boards accurately in location, alignment, and elevation to support and anchor electrical materials and equipment. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members. Attach to substrates as required to support applied loads. Maintain at least 100 mm (4 in) from bottom of plywood equipment boards and the finished floor surface.
- 2.12.4 Unless directed otherwise in field, plywood equipment boards shall be 2440 mm (8 ft) high by 19 mm (3/4 in) deep by length shown on drawings (as dimensioned or as scaled) or length as required to accommodate equipment if not indicated on drawings. Unless directed otherwise in field, provide plywood equipment boards for all indoor surface mounted panelboards and systems "head-end" equipment for all applications where located in mechanical or electrical rooms/areas and only where specifically shown on drawings for all other applications.

2.13 ROOF SUPPORTS

- 2.13.1 High-density polyethylene platform and base, height adjustable with rounded corners and edges to reduce likelihood of roof penetration.
- 2.13.2 Large surface area to spread the weight of supported objects including conduits, and cable trays over a large surface footprint.
- 2.13.3 No penetration of the waterproof membrane.
- 2.13.4 Self drains water, rot proof, and sunlight resistant.
- 2.13.5 Manufacturers:
 - 2.13.5.1 Thomas & Betts Superstrut Adjustable Universal Support.
 - 2.13.5.2 Eaton Dura-Blok series.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Obtain permission from the Consultant before drilling or cutting structural members.
 - 3.1.2 Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.
 - 3.1.3 Install surface-mounted cabinets and panelboards with minimum of four anchors.
 - 3.1.4 In wet and damp locations use steel channel supports to stand cabinets and panelboards 25 mm (1 in) off wall.
 - 3.1.5 Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.
 - 3.1.6 Provide inserts, sleeves, equipment supports and hangers, sealing of sleeves and openings, as required for all electrical work. Ensure that the load onto structures does not
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- exceed the maximum loading per square metre as shown on Structural Drawings or as directed by the Consultant.
- 3.1.7 Provide insets, holes, anchor bolts and sleeves in time when walls, floors, and roof are erected.
 - 3.1.8 Place insets only in structural members and not in the finishing material.
 - 3.1.9 Secure all supports and hangers to the structure unless noted otherwise.
 - 3.1.10 Suspend hanger rods from approved concrete inserts and from beam clamps. Obtain Consultant's approval before welding to steel structural members.
 - 3.1.11 Secure supports to precast concrete members to inserts originally cast into the members or by rods passing between the members and connected to a steel plate bearing.
 - 3.1.12 Sealing of Sleeves and Openings to Maintain Fire Rating
 - 3.1.12.1 Use Dow-Corning #3-6548 'Silicone RTV' foam, Thomas & Betts 'Flamesafe' firestop system, Electrovert 'Flameseal' firestop putty, or approved equal materials installed in accordance with the manufacturer's specifications and recommendations.
 - 3.1.12.2 Submit data sheets for review prior to installation.
 - 3.1.13 Supports
 - 3.1.13.1 All conduits, panels, etc. to be securely and adequately supported.
 - 3.1.13.2 Where more than three conduits run together, conduit racks to be used.
 - 3.1.13.3 Single runs of conduit to be supported by galvanized conduit straps or ring bolt type hangers. Tie wire or perforated metal strap hangers will NOT be accepted.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Rigid steel conduit.
- 1.1.2 Flexible metal conduit.
- 1.1.3 Liquid tight flexible metal conduit.
- 1.1.4 Electrical metallic tubing (EMT).
- 1.1.5 Rigid PVC conduit.
- 1.1.6 Fittings and conduit bodies.

1.2 REFERENCES

- 1.2.1 CSA Group:
 - 1.2.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.2.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.2.1.3 CSA C22.2 No. 45.1:22 – Electrical rigid metal conduit – steel.
 - 1.2.1.4 CSA C22.2 No. 56-17 (R2022), Flexible metal conduit and liquid-tight flexible metal conduit.
 - 1.2.1.5 CSA C22.2 No. 83.1:07 (R2022), Electrical Metallic Tubing – Steel.
 - 1.2.1.6 CSA C22.2 No. 211.1-06 (R2021), Rigid types EB1 and DB2/ES2 PVC conduit.
 - 1.2.1.7 CSA C22.2 No. 211.2-06 (R2021), Rigid PVC (unplasticized) conduit.
 - 1.2.1.8 CSA C22.2 No. 227.1:19 (R2023), Electrical nonmetallic tubing.
 - 1.2.1.9 CSA C22.2 No. 227.2.1 is a Trinational standard with NMX-J-764-ANCE and UL 1660.
 - 1.2.1.10 CSA C22.2 No. 227.2.1:19 (R2023), Liquid-tight flexible nonmetallic conduit.
 - 1.2.1.11 CSA C22.2 No. 2420-09 (R2019), Belowground reinforced thermosetting resin conduit (RTRC) and fittings.

1.3 RECORD DOCUMENTATION

- 1.3.1 Accurately record actual routing of conduits larger than 51 mm (2 in).
- 1.3.2 Accurately record actual routing of all conduits installed below grade, regardless of size, including whether direct buried or installed in concrete duct bank.

1.4 REGULATORY REQUIREMENTS

- 1.4.1 Provide products listed and classified by CSA (Canadian Standards Association) as suitable for purpose specified and shown.

1.5 DELIVERY, STORAGE, AND HANDLING

- 1.5.1 Accept conduit on site. Inspect for damage.
- 1.5.2 Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

1.6 PROJECT CONDITIONS

- 1.6.1 Verify that field measurements are as shown on drawings.
 - 1.6.2 Verify routing and termination locations of conduit prior to rough-in.
 - 1.6.3 Conduit routing, if shown on drawings, is approximate unless dimensioned. Route as required to provide a complete wiring system.
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2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Where products are listed in this section based on a single manufacturer, the equivalent product from the following manufacturers is acceptable:
 - 2.1.1.1 Appleton.
 - 2.1.1.2 Columbia-MBF.
 - 2.1.1.3 Crouse-Hinds by Eaton.
 - 2.1.1.4 Hubbell.
 - 2.1.1.5 Thomas & Betts Ltd.

2.2 RIGID METAL CONDUIT

- 2.2.1 Rigid metal conduit: to CSA C22.2 No. 45, hot dipped galvanized steel, threaded.
- 2.2.2 Epoxy coated conduit: to CSA C22.2 No. 45, with zinc coating and corrosion resistant epoxy finish inside and outside.
- 2.2.3 Fittings and conduit bodies: Material to match conduit.

2.3 FLEXIBLE METAL CONDUIT

- 2.3.1 Flexible metal conduit: to CSA C22.2 No. 56, interlocked steel construction.
- 2.3.2 Fittings: CSA C22.2 No. 56.

2.4 LIQUID TIGHT FLEXIBLE METAL CONDUIT

- 2.4.1 Description: Interlocked steel construction with PVC jacket.
- 2.4.2 Fittings: CSA C22.2 No. 56.

2.5 ELECTRICAL METALLIC TUBING (EMT)

- 2.5.1 Description: CSA C22.2 No. 83.1; galvanized tubing.
- 2.5.2 Fittings and Conduit Bodies: CSA C22.2 No. 83.1; steel type.

2.6 ELECTRICAL NON-METALLIC TUBING (ENT)

- 2.6.1 To CSA C22.2 No. 227.1.

2.7 NON-METALLIC CONDUIT

- 2.7.1 Rigid Type EB1 PVC Conduit: to CSA C22.2 No. 211.1.
- 2.7.2 Rigid Type DB2/ES2 PVC Conduit: to CSA C22.2 No. 211.1.

2.8 CONDUIT, FITTINGS, AND ACCESSORIES

- 2.8.1 Conduit accessories, conduits and fittings conforming to CSA Standard C22.2 No. 18-1972.
 - 2.8.2 Provide rain tight connectors, couplings, fittings, junction boxes, pull boxes and surface outlet boxes shall be used for surface conduit installations exposed to moisture or in sprinklered buildings.
 - 2.8.3 Rigid conduit bushings:
 - 2.8.3.1 Thomas & Betts Ltd. - Series 5031.
 - 2.8.4 EMT Connectors:
 - 2.8.4.1 Thomas & Betts Ltd. - Steel City TC121A series.
 - 2.8.5 Ground Bushings:
 - 2.8.5.1 Thomas & Betts – Blackjack or 1220 series.
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- 2.8.6 Flexible conduit connectors:
 - 2.8.6.1 Thomas & Betts Ltd. - Series 3110.
 - 2.8.6.2 EMT couplings: steel concrete tight to match connectors.
- 2.8.7 Terminate rigid conduit entering boxes or enclosures with nylon insulated steel threaded bushings.
 - 2.8.7.1 Thomas & Betts – 8125 series.
- 2.8.8 Terminate EMT entering boxes or enclosures with nylon insulated steel concrete tight connectors.
- 2.8.9 Terminate flexible conduit entering boxes or enclosures with nylon insulated steel connectors.
 - 2.8.9.1 Thomas & Betts – 5332 series.

3 EXECUTION

3.1 PREPARATION

- 3.1.1 Produce layout sketches of conduit runs through mechanical and electrical service areas, through corridors, and other congested areas in order to resolve any interferences with other work, and to determine the most efficient route to run the conduit.

3.2 INSTALLATION

- 3.2.1 Minimum size: 21 mm (3/4 in) unless otherwise specified.
- 3.2.2 Conceal all conduit except in mechanical rooms and electrical rooms, or unless otherwise indicated in this specification, or noted on the drawings. Surface conduit work is not permitted unless specifically noted.
- 3.2.3 Install wiring in conduit unless otherwise specified. Where conduit sizes are not shown on drawings, provide conduits sized in accordance with Ontario Electrical Safety Code, CSA C22.1. When conduits are indicated, they are the minimum size required, and must be increased to suit the length of run or voltage drop requirements.
- 3.2.4 Conduit use:
 - 3.2.4.1 Unless otherwise specified below or shown on the drawings, all systems shall be installed in electrical metallic tubing (EMT).
 - 3.2.4.2 Equipment subject to vibration:
 - (1) Use liquid tight flexible metal conduit for connections to transformers, motors, and equipment, subject to vibration and movement.
 - 3.2.4.3 Outdoor locations, above grade: use rigid steel.
 - 3.2.4.4 Underground: Use rigid PVC conduit for wiring in slabs on grade, and wiring below grade.
 - 3.2.4.5 Wet and damp locations:
 - (1) Use rigid steel.
 - (2) Use liquid tight flexible metal conduit for connections to transformers, motors, and equipment, subject to vibration and movement.
 - 3.2.4.6 Dry locations:
 - (1) Concealed in metal stud partitions:
 - (A) Use electrical metallic tubing.
 - (B) Use of AC90 (Bx) as described in Section 26 05 19.
 - (2) Concealed in concrete: Use electrical non-metallic tubing or rigid PVC.
 - (3) Exposed areas: Use electrical metallic tubing.

- (4) Use flexible metal conduit for connections to transformers, motors, and equipment, subject to vibration and movement.
 - (5) Use liquid tight flexible metal conduit below raised floors for connections to all devices.
 - (6) Aluminium conduit may be used, in lieu of steel conduit, in clean and dry locations, but shall not be used in poured concrete, or for signal and intercommunication systems wiring.
 - (7) Raceways installed less than 2 m above grade in an area where they are subject to mechanical damage (i.e. the Apparatus Bay), shall be of the rigid steel type or protected by a steel guard of not less than no. 10 MSG, adequately secured in place.
 - (8) Use epoxy coated conduit in corrosive areas.
 - 3.2.4.7 Equipment in sprinklered spaces:
 - (1) Provide CSA certified sealing rings for rigid steel galvanized conduit and CSA certified raintight connectors for steel galvanized electrical metallic tubing (EMT) where conduits enter the top or the sides of enclosures.
 - 3.2.4.8 Telecommunications conduits: in accordance with Section 27 05 28.
 - 3.2.5 Arrangement and supports:
 - 3.2.5.1 Arrange supports to prevent misalignment during wiring installation.
 - 3.2.5.2 Arrange conduit to maintain headroom and present neat appearance.
 - 3.2.5.3 Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.
 - 3.2.5.4 Group related conduits; support using conduit rack.
 - 3.2.5.5 Construct rack using steel channel; provide space on each for 25 per cent additional conduits.
 - 3.2.5.6 Fasten conduit supports to building structure and surfaces to Section 26 05 29.
 - 3.2.5.7 Do not support conduit with wire or perforated pipe straps.
 - 3.2.5.8 Remove wire used for temporary supports.
 - 3.2.5.9 Do not attach conduit to ceiling support wires.
 - 3.2.5.10 Route exposed conduit parallel and perpendicular to walls.
 - 3.2.5.11 Route conduit installed above accessible ceilings parallel and perpendicular to walls.
 - 3.2.5.12 Route conduit in and under slab from point-to-point.
 - 3.2.5.13 In damp and unheated areas, avoid moisture traps; provide junction box with drain fitting at low points in conduit system.
 - 3.2.5.14 Provide suitable fittings to accommodate expansion and deflection where conduit crosses expansion joints.
 - 3.2.6 Clearances:
 - 3.2.6.1 Maintain adequate clearance between conduit and piping.
 - 3.2.6.2 Maintain 300 mm (12 in) clearance between conduit and surfaces with temperatures exceeding 40°C.
 - 3.2.7 Conduit bends:
 - 3.2.7.1 Install no more than equivalent of three 90 degree bends between boxes.
 - (1) Use conduit bodies to make sharp changes in direction, as around beams.
 - (2) Use hydraulic one-shot bender to fabricate bends in metal conduit larger than 50 mm size or provide prefabricated conduit bends.
 - 3.2.8 Install wall entrance seals where conduits pass through exterior walls below grade.
 - 3.2.9 Provide expansion coupling in conduit runs at building expansion joints and in long runs subject to thermal expansion, all in accordance with manufacturer recommendations.
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- 3.2.10 Cut conduit square using saw or pipe cutter; de-burr cut ends.
- 3.2.11 Bring conduit to shoulder of fittings; fasten securely.
- 3.2.12 Use suitable caps to protect installed conduit against entrance of dirt and moisture.
- 3.2.13 Use conduit hubs or sealing locknuts to fasten conduit and to cast boxes.
- 3.2.14 Provide suitable pull string in each empty conduit except sleeves and nipples.
- 3.2.15 Ground and bond conduit to Section 26 05 26.
- 3.2.16 Identify conduit to Section 26 05 53.
- 3.2.17 Flexible conduit and armoured cable will be accepted for a maximum length of 1500 mm for final connection to lighting fixtures. Do not connect from fixture to fixture.

3.3 CLEANING

- 3.3.1 Conduit manufacturer's touch-up enamel shall be used to repair all scratches and gouges on epoxy-coated conduit.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Wall and ceiling outlet boxes.
- 1.1.2 Pull and junction boxes.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 27 16 – Electrical Cabinets and Enclosures.
- 1.2.2 Section 26 27 26 – Wiring Devices: Wall plates in finished areas, floor box service fittings, fire-rated poke-through fittings, and access floor boxes.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.1.1.1 CSA C22.2 No. 18.1:13 (R2022), Metallic outlet boxes.
- 1.3.1.3 CSA C22.2 No. 18.1-13 (R2022) – Metallic Outlet Boxes (Tri-national standard, with UL 514A and ANCE NMJ-J-023/1).
- 1.3.1.4 CSA C22.2 No. 40-17 - Junction and Pull Boxes.
- 1.3.1.5 CSA C22.2 No. 85-14 (R2018) – Rigid PVC Boxes and Fittings.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Record actual locations and mounting heights of outlet, pull, and junction boxes on project record documents.

1.5 REGULATORY REQUIREMENTS

- 1.5.1 Provide products listed and classified by CSA (Canadian Standards Association) as suitable for the purpose specified and indicated.

2 PRODUCTS

2.1 OUTLET BOXES

- 2.1.1 Sheet Metal Outlet Boxes: CSA C22.2 No. 18.1, galvanized steel.
 - 2.1.1.1 Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 13 mm male fixture studs where required.
 - 2.1.1.2 Concrete Ceiling Boxes: Concrete type.
- 2.1.2 Non-metallic Outlet Boxes: CSA C22.2 No. 18.1.
- 2.1.3 Cast Boxes: CSA C22.2 No. 18.1, Type FD, aluminum. Provide gasketed cover by box manufacturer. Provide threaded hubs.
- 2.1.4 Wall Plates for Finished Areas: As specified in Section 26 27 26.

2.2 PULL BOXES AND JUNCTION BOXES

- 2.2.1 Sheet Metal Boxes: CSA C22.2 No. 18.1, galvanized steel.
 - 2.2.2 Hinged Enclosures: As specified in Section 26 27 16.
 - 2.2.3 Surface Mounted Cast Metal Box: CSA C22.2 No. 18.1, Type 4; flat-flanged, surface mounted junction box:
 - 2.2.3.1 Material: Cast aluminum.
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- 2.2.3.2 Cover: Provide with ground flange, neoprene gasket, and stainless steel cover screws.

2.3 OUTLET BOXES

- 2.3.1 Conform to CSA C22.2 No. 18.1.
- 2.3.2 Where 103 mm (4 inch) square outlet boxes are installed in exposed concrete or cinder block finished areas, blocks will be cut as described in Division 04 as instructed under this Section. Cut openings to provide a close fit to boxes and covers so that edges of openings are not visible after installation of plates. Use of mortar to patch up openings that are cut too large or to patch ragged edges is not permitted.
- 2.3.3 Ceiling boxes: 103 mm (4 inch) octagon or square, complete with fittings, where required to support fixtures.
- 2.3.4 Switch and receptacle boxes:
- 2.3.4.1 103 mm (4 inch) square with plaster ring, where flush mounted in plaster walls.
- 2.3.4.2 Iberville 1104 series box, or equal, where flush mounted in wood or drywall, with stud fasteners as required.
- 2.3.4.3 Masonry boxes in masonry walls.
- 2.3.5 Where boxes are surface mounted in unfinished areas they shall be FS conduits.
- 2.3.6 Standard outlet boxes manufactured from code gauge galvanized steel.
- 2.3.7 Provide a suitable outlet box for each light, switch, receptacle, or other outlet, approved for the area it is to be installed.
- 2.3.8 Support outlet boxes independently of conduit and cable.
- 2.3.9 Locate outlet boxes, mounted in hung ceiling space, so they do not obstruct or interfere with the removal of lay-in ceiling tiles.
- 2.3.10 Offset outlet boxes, shown back to back in partitions, horizontally a minimum 150 mm (6 inch) to minimize noise transmission between adjacent rooms.
- 2.3.11 Use gang boxes at locations where more than one device, of the same system only, is to be mounted. Utilize separate boxes for each system.
- 2.3.12 Use tile wall covers where 103 mm (4 inch) square outlet boxes are installed in exposed concrete or cinder block in finished areas.
- 2.3.13 Provide flush mount boxes, panels, cabinets, and electrical devices, which are installed in finished areas, with suitable flush trims and doors or covers, unless specifically noted otherwise.
- 2.3.14 Provide pre-formed polyethylene vapour barriers for all boxes located in walls with internal vapour barriers.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Verify locations of floor boxes prior to rough-in.

3.2 INSTALLATION

- 3.2.1 Install boxes to CSA C22.1.
- 3.2.2 Install in locations as shown on drawings, and as required for splices, taps, wire pulling, equipment connections and compliance with regulatory requirements.
- 3.2.3 Set wall mounted boxes at elevations to accommodate mounting heights indicated.
- 3.2.4 Electrical boxes are shown on drawings in approximate locations unless dimensioned. Adjust box location up to 3 m (10 feet) if required to accommodate intended purpose.
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- 3.2.5 Orient boxes to accommodate wiring devices oriented as specified in Section 26 27 26.
- 3.2.6 Maintain headroom and present neat mechanical appearance.
- 3.2.7 Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
- 3.2.8 Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 150 mm (6 inch) from ceiling access panel or from removable recessed luminaire.
- 3.2.9 Install boxes to preserve fire resistance rating of partitions and other elements, using materials and methods.
- 3.2.10 Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
- 3.2.11 Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.
- 3.2.12 Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.
- 3.2.13 Use flush mounting outlet box in finished areas.
- 3.2.14 Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.
- 3.2.15 Do not install flush mounting box back-to-back in walls; provide minimum 150 mm (6") separation. Provide minimum 600 mm (24") separation in acoustic rated walls.
- 3.2.16 Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
- 3.2.17 Use stamped steel bridges to fasten flush mounting outlet box between studs.
- 3.2.18 Install flush mounting box without damaging wall insulation or reducing its effectiveness.
- 3.2.19 Use adjustable steel channel fasteners for hung ceiling outlet box.
- 3.2.20 Do not fasten boxes to ceiling support wires.
- 3.2.21 Support boxes independently of conduit.
- 3.2.22 Use gang box where more than one device is mounted together. Do not use sectional box.
- 3.2.23 Use gang box with plaster ring for single device outlets.
- 3.2.24 Use cast outlet box in exterior locations exposed to the weather.
- 3.2.25 Use cast outlet box in wet locations.
- 3.2.26 Set floor boxes level.
- 3.2.27 Large pull boxes: Use hinged enclosure in interior dry locations, surface-mounted cast metal box in other locations.

3.3 ADJUSTING

- 3.3.1 Adjust floor box flush with finish flooring material.
- 3.3.2 Adjust flush-mounting outlets to make front flush with finished wall material.
- 3.3.3 Install knockout closures in unused box openings.

3.4 CLEANING

- 3.4.1 Clean interior of boxes to remove dust, debris, and other material.
- 3.4.2 Clean exposed surfaces and restore finish.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Cables installed in ducts.
- 1.1.2 Direct buried cables.
- 1.1.3 Handholes.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 31 23 00 – Excavation and Backfill.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.3 No. 7-15, Underground systems.
- 1.3.2 Institute of Electrical and Electronics Engineers:
 - 1.3.2.1 IEEE 835-1994, Standard Power Cable Ampacity Tables.
- 1.3.3 Insulated Cable Engineers Association, Inc. (ICEA).

1.4 SUBMITTALS

- 1.4.1 Submit records of underground utility locates, indicating location plan of existing utilities as found in field and clearance record from utility authority and location plan of relocated and abandoned services, as required.
- 1.4.2 Feeder ampacity calculations from cable manufacturer for any duct banks or direct buried feeders not constructed in accordance with OESC to demonstrate compliance with IEEE 835.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Record documentation:
 - 1.5.1.1 Records of underground utility locates.
 - 1.5.1.2 Record as-constructed location of all underground conduits and feeders on as-built drawings regardless of conduit size.

2 PRODUCTS

2.1 FILL MATERIALS

- 2.1.1 Sand fill: clean, natural sand and gravel material, free from silt, clay, loam, friable or soluble materials and vegetable matter.
- 2.1.2 Backfill material: Selected material from excavation or other sources, reviewed by the Consultant, unfrozen and free from rocks larger than 75 mm (3 inch), rock with sharp angular surfaces, cinders, ashes, sods, refuse, or other deleterious materials.

2.2 DIRECT BURIED AND CONCRETE ENCASED CONDUITS

- 2.2.1 Rigid Type DB2/ES2 PVC conduit to Section 26 05 33.13.

2.3 CONDUCTORS

- 2.3.1 RWU90, in accordance with Section 26 05 19 for use in direct buried applications, and in below grade conduits and duct banks.
-

2.4 TRACER WIRE

- 1.1.1 Direct burial rated tracer wire: single, solid copper, 12 AWG minimum size with 30 mm PVC jacket.
 - 1.1.1.1 Provide red jacket for circuits 120 V and higher.
 - 1.1.1.2 Provide orange jacket for communications conduits and services lower than 120 V.

2.5 HANDHOLES

- 2.5.1 460 mm (18") round handhole.
- 2.5.2 Precast concrete, to OPSD 2112.02 standard, suitable for use in vehicular traffic areas.
- 2.5.3 Manufacturers:
 - 2.5.3.1 Armtec-Brooklin Concrete.
 - 2.5.3.2 Hy-Grade Precast Concrete.
 - 2.5.3.3 Utilicon.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Perform locates prior to start of work.

3.2 EXCAVATION AND FILL

- 3.2.1 In accordance with Section 31 23 00.
- 3.2.2 Trenching:
 - 3.2.2.1 Excavate to dimensions indicated. Ensure trench width is sufficient to accommodate mechanical vibratory compactor.
 - 3.2.2.2 Do not leave open trench at end of day's operation.
- 3.2.3 Backfilling:
 - 3.2.3.1 Do not proceed with backfilling operations until Electrical Inspection Authority has inspected and approved installation.
- 3.2.4 Restoration:
 - 3.2.4.1 Restore surface of work area to conditions existing prior to execution of work.
 - 3.2.4.2 After backfilling trench, provide new topsoil as required to follow minimum depths after settlement of 100 mm (4 in) for grass seeded areas.
 - 3.2.4.3 Restore surface of paved areas to match existing.

3.3 CABLE INSTALLATION IN DUCTS

- 3.3.1 Install cables as indicated in ducts.
 - 3.3.2 Do not pull spliced cables inside ducts.
 - 3.3.3 Install multiple cables in duct simultaneously.
 - 3.3.4 Use CSA approved lubricants of type compatible with cable jacket to reduce pulling tension.
 - 3.3.5 To facilitate matching of colour coded multiconductor control cables reel off in same direction during installation.
 - 3.3.6 Before pulling cable into ducts and until cables are properly terminated, seal ends of lead covered cables with wiping solder; seal ends of non-leaded cables with moisture seal tape.
 - 3.3.7 After installation of cables, seal duct ends with duct sealing compound.
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3.4 DIRECT BURIAL OF CABLE

- 3.4.1 Provide sand bed as indicated.
- 3.4.2 Lay cables maintaining 75 mm (3 in) clearance from each side of trench to nearest cable. Do not pull cable into trench.
- 3.4.3 Provide offsets for thermal action and minor earth movements. Offset cable 150 mm for each 60 m run, maintaining minimum cable separation and bending radius requirements.
- 3.4.4 Install treated planks on cables for mechanical protection. Install above cables and below markers.
- 3.4.5 Cable separation:
 - 3.4.5.1 Maintain 75 mm (3 in) minimum separation between cables of different circuits.
 - 3.4.5.2 Maintain 300 mm (12 in) horizontal separation between low and high voltage cables.
 - 3.4.5.3 When low voltage cables cross high voltage cables maintain 300 mm (12 in) vertical separation with low voltage cables in upper position.
 - 3.4.5.4 At crossover, maintain 75 mm (3 in) minimum vertical separation between low voltage cables and 150 mm between high voltage cables.
 - 3.4.5.5 Maintain minimum 300 mm (12 in) horizontal separation between cables or conduits and gas service where installed in the same trench.

3.5 MARKERS

- 3.5.1 Mark cable every 150 m along duct runs and changes in direction.
- 3.5.2 Mark underground splices.
- 3.5.3 Where markers are removed to permit installation of additional cables, reinstall existing markers.
- 3.5.4 Install cedar post type markers.
- 3.5.5 Lay concrete markers flat and centred over cable with top flush with finish grade.
- 3.5.6 Where warning tape is used to comply with 2021 OESC Rule 12-012(11) or latest edition, bury the tape approximately halfway between the installation and grade level, covering the width of the raceways or cables installed, in accordance with OESC Bulletin 12-2- (latest version).
- 3.5.7 Tracer wires:
 - 1.1.1.3 Provide direct burial rated tracer wire above all underground raceways and duct banks for power, control/monitoring, lighting and branch circuits, and communications raceways.
 - 1.1.1.4 Install tracer wire above the warning tape.

3.6 FIELD QUALITY CONTROL

- 3.6.1 Perform tests in accordance with Section 26 05 00.
 - 3.6.2 Perform tests using qualified personnel. Provide necessary instruments and equipment.
 - 3.6.3 Check phase rotation and identify each phase conductor of each feeder.
 - 3.6.4 Check each feeder for continuity, short circuits and grounds. Ensure resistance to ground of circuits is not less than 50 megohms.
 - 3.6.5 Pre-acceptance tests:
 - 3.6.5.1 After installing cable but before splicing and terminating, perform insulation resistance test with 1000 V megger on each phase conductor.
 - 3.6.5.2 Check insulation resistance after each splice and/or termination to ensure that cable system is ready for acceptance testing.
 - 3.6.6 Acceptance Tests:
 - 3.6.6.1 Ensure that terminations and accessory equipment are disconnected.
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- 3.6.6.2 Ground shields, ground wires, metallic armour, and conductors not under test.
- 3.6.6.3 High Potential (Hipot) Testing.
 - (1) Conduct hipot testing in accordance with manufacturer's recommendations.
- 3.6.7 Provide Owner with list of test results showing location at which each test was made, circuit tested and result of each test.
- 3.6.8 Non-Conforming Work: Remove and replace entire length of cable if cable fails to meet any of test criteria.

3.7 WASTE MANAGEMENT

- 3.7.1 Remove from site and dispose of all packaging materials at appropriate recycling facilities.
- 3.7.2 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
- 3.7.3 Do not dispose of unused sealant material into sewer system, into streams, lakes, onto ground or in other location where it will pose health or environmental hazard.
- 3.7.4 Divert unused metal and wiring materials from landfill to metal recycling facility as approved by Departmental Representative.
- 3.7.5 Do not dispose of preservative treated wood through incineration.
- 3.7.6 Do not dispose of preservative treated wood with other materials destined for recycling or reuse.
- 3.7.7 Dispose of treated wood, end pieces, wood scraps and sawdust at sanitary landfill approved by Departmental Representative.
- 3.7.8 Fold up metal banding, flatten and place in designated area for recycling.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Sleeves, sealing of sleeves and openings, as required for all electrical work.

1.2 SUBMITTALS

- 1.2.1 Submit data sheets for firestopping in accordance with Section 01 33 00.
- 1.2.2 Submit copies of firestopping drawings with ULC certificate and system number for each specific installation.
- 1.2.3 Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.
- 1.2.4 Submit dimensioned location drawings indicating required sleeves and formed openings in structural poured concrete or precast concrete construction or in roofing, and locations of cutting or drilling required for Electrical work.

2 PRODUCTS

2.1 SLEEVES

- 2.1.1 Galvanized steel sleeves:
 - 2.1.1.1 24 gauge with an integral flange at one (1) end to secure sleeve to formwork construction.
 - 2.1.1.2 Schedule 40 pipe.
- 2.1.2 Schedule 40 PVC sleeves.

2.2 SLEEVE SEALS

- 2.2.1 Manufacturers
 - 2.2.1.1 Hilti Canada.
 - 2.2.1.2 Specified Technologies Inc.
 - 2.2.1.3 3M Canada Inc.
 - 2.2.1.4 Tremco.
 - 2.2.1.5 A/D Fire Protection Systems.
 - 2.2.1.6 Nelson.
- 2.2.2 Asbestos-free, elastomeric materials and intumescent materials, tested, listed, and labelled by ULC in accordance with CAN/ULC-S115, and CAN/ULC-S101 for installation in ULC designated firestopping, and smoke seal systems to provide a positive fire, water and smoke seal and a fire resistance rating (flame, hose stream and temperature) no less than fire rating for surrounding construction.
- 2.2.3 Materials are to be compatible with abutting dissimilar materials and finishes and complete with primers, damming and back-up materials, supports, and anchoring devices in accordance with firestopping manufacturer's recommendations and ULC tested assembly. Coordinate material requirements with trades supplying abutting areas of materials.
- 2.2.4 Maintain fire rating of separation in accordance with architectural drawings.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Where conduits and conductors pass through structural poured concrete, provide sleeves of type suitable for application, and approved by local governing codes.
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- 3.1.2 Sleeves in concrete slabs, except as noted below, are to be No. 24 gauge or equivalent, with an integral flange to secure sleeves for formwork construction.
- 3.1.3 Sleeves in waterproof concrete slabs and in other slabs where waterproof sleeves are required are to be lengths of Schedule 40 pipe sized to extend 100 mm (4") above floor.
- 3.1.4 Sleeves in poured concrete walls and foundation are to be Schedule 40 pipe.
- 3.1.5 Through interior walls, use standard weight steel pipes, conduit, or galvanized steel. Cut flush with finished surfaces. Check room finish schedules.
- 3.1.6 Through exterior walls above grade, floors, and roof use standard weight steel pipes, machine cut, flush with finished surface inside and to suit flashing outside.
- 3.1.7 Through exterior walls below grade, water-proofed floors, and other water-proof walls, use heavy weight cast iron pipes, machine cut. Extend sleeves 100 mm (4") above finished floors, and cut flush with underside of floor.
- 3.1.8 Size sleeves, unless otherwise noted, to leave 13 mm (1/2") clearance around conduit, duct, conductor, etc. Void between sleeves and conduit, duct, conductors, etc., to be packed and sealed for length of sleeves as in accordance with article entitled "Sleeve Seals" specified in this Section. Pack and seal sleeves set in exterior walls with governing authority approved materials suitable for application and pack both ends of sleeves watertight with approved permanently flexible and water tight materials. Coordinate exact responsibility of work with General Trades Contractor.
- 3.1.9 Submit to concrete reinforcement detailer at proper time, drawings indicating required sleeves, recesses and formed openings in poured concrete work. Completely and accurately dimension such drawings and relate sleeves, recesses and formed openings to suitable grid lines and elevation datum.
- 3.1.10 Supply sleeves of a water protecting type in accordance with detail found on drawings for installation in following locations:
 - 3.1.10.1 in Mechanical and Fan Room floor slabs, except where on grade;
 - 3.1.10.2 in slabs over Mechanical, Fan, Electrical and Telephone Equipment Rooms or closets;
 - 3.1.10.3 in floors equipped with waterproof membranes.
- 3.1.11 "Gang" type sleeving to be permitted only with approval of Owner and reviewed with the Consultant.
- 3.1.12 Terminate sleeves for work which is exposed, so that sleeve is flush at both ends with wall, partition, or slab surface such that sleeve may be covered completely by escutcheon plates.
- 3.1.13 Sleeves are not required in interior walls and dry area floors where conduit is installed ahead of floor construction.
- 3.1.14 Seal all openings and sleeves after installation of equipment:
 - 3.1.14.1 With an approved material to maintain fire rating where sleeves and openings pass through fire separations and floors.
 - 3.1.14.2 With an approved material to maintain fire rating for sleeves and openings provided for future equipment.
 - 3.1.14.3 Flash all conduits and systems passing through roof or built into an outside wall, or a waterproof floor.
 - 3.1.14.4 Provide copper flashing for sleeves passing through exterior walls or waterproof floors.
- 3.1.15 Provide all flashing and waterproofing for sleeves through roof and exterior walls to the requirements of Division 07.
- 3.1.16 Firestop sleeves in accordance with the manufacturer's specifications and recommendations.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Tested firestop systems used in penetrations for the passage of cables, conduit, and other electrical equipment through fire-rated vertical barriers (walls and partitions), horizontal barriers (floor/ceiling assemblies), and vertical service shaft walls and partitions.

1.2 RELATED REQUIREMENTS

- 1.2.1 Coordinate work of this section with work of other sections as required to properly execute the work and as necessary to maintain satisfactory progress of the work of other sections, including:
 - 1.2.1.1 Section 07 84 00 – Firestopping and Smoke Seals.
 - 1.2.1.2 Section 27 05 44 – Sleeves and Sleeve Seals for Communications Pathways and Cabling.

1.3 REFERENCES

- 1.3.1 Underwriter's Laboratories (UL) and Underwriters Laboratories of Canada (ULC):
 - 1.3.1.1 Test Requirements: CAN/ULC-S115:2018, Standard Method of Fire Tests of Firestop Systems.
 - 1.3.1.2 Underwriters Laboratories of Canada (ULC) runs CAN/ULC-S115:2018 under their designation of ULC-S115:2018 and publishes the results in their "FIRE RESISTANCE RATINGS DIRECTORY" that is updated annually.
 - 1.3.1.3 Underwriters Laboratories (UL) of Northbrook, IL runs ASTM E-814 under their designation of UL 1479 and publishes the results in their "FIRE RESISTANCE DIRECTORY" that is updated annually. UL tests that meet the requirements of ULC-S115-M are given a cUL listing and are published by UL in their "Products Certified for Canada (cUL) Directory.
 - 1.3.1.4 CAN/ULC-S102:2018, Standard Test Method for Surface Burning Characteristics of Building Materials and CAN/ULC-S101 Fire Endurance Tests of Building Construction and Materials.
 - 1.3.2 ASTM:
 - 1.3.2.1 Omega Point Laboratories runs ASTM E-814 and publishes the results annually in their "Omega Point Laboratories Directory".
 - 1.3.2.2 Inspection Requirements: ASTM E 2174, "Standard Practice for On-site Inspection of Installed Fire Stops.", and ASTM E2393 Standard Practice for On-Site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers.
 - 1.3.2.3 Test Requirements: ASTM E 2307, "Standard Test Method for Determining Fire Resistance of Perimeter Fire Barrier Systems Using Intermediate-Scale, Multi-story Test Apparatus".
 - 1.3.2.4 ASTM D6904, "Standard Practice for Resistance to Wind Driven Rain for Exterior Coatings Applied on Masonry".
 - 1.3.2.5 ASTM C 679, "Standard Test Method for Tack-Free Time of Elastomeric Sealants".
 - 1.3.3 International Firestop Council Guidelines for Evaluating Firestop Systems Engineering Judgments.
 - 1.3.4 Ontario Building Code.
 - 1.3.5 Ontario Electrical Safety Code.
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1.4 DEFINITIONS

- 1.4.1 Firestopping: Material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and hot gases through penetrations in fire rated wall and floor assemblies.

1.5 SUBMITTALS

- 1.5.1 Submit Product Data: Manufacturer's specifications and technical data for each material including the composition and limitations, documentation of ULC or cUL firestop systems to be used and manufacturer's installation instructions to comply with Section 01 33 00.
- 1.5.2 Manufacturer's engineering judgment identification number and drawing details when no ULC or cUL system is available for an application. Engineered judgment must include both project name and contractor's name who will install firestop system as described in drawing.
- 1.5.3 Submit material safety data sheets provided with product delivered to project site.
- 1.5.4 Submit shop drawings in accordance with Section 01 33 00:
- 1.5.4.1 Submit complete cUL, ULC, or equivalent approved systems for all applications. Ensure the listing is clearly noted on the submittal.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 On completion of firestopping and smoke sealing installation, submit a Letter of Assurance to the Consultant certifying the firestopping and smoke sealing installation has been carried out throughout the building to electrical service penetrations and that installation has been done in strict accordance with requirements of the Ontario Building Code, any applicable municipal bylaws, ULC requirements, and manufacturer's instructions.

1.7 QUALITY ASSURANCE

- 1.7.1 Fire-Test-Response Characteristics: Provide through-penetration fire stop systems and fire-resistive joint systems that comply with specified requirements of tested systems.
- 1.7.2 Firestop System installation must meet requirements of CAN/ULC-S115 tested assemblies that provide a fire rating as shown in Section 2.1 Clauses 4, 5, 6, and 7 below.
- 1.7.3 Proposed firestop materials and methods shall conform to applicable governing codes having local jurisdiction.
- 1.7.4 Firestop Systems do not re-establish the structural integrity of load bearing partitions/assemblies, or support live loads and traffic. Installer shall consult the structural engineer prior to penetrating any load bearing assembly.
- 1.7.5 For those firestop applications that exist for which no ULC or cUL tested system is available through a manufacturer, a manufacturer's engineering judgment derived from similar ULC or cUL system designs or other tests will be submitted to local authorities having jurisdiction for their review and approval prior to installation. Engineering judgment drawings must follow requirements set forth by the International Firestop Council.

1.8 INSTALLER QUALIFICATIONS

- 1.8.1 Engage an experienced Installer who is certified, licensed, or otherwise qualified by the firestopping manufacturer as having the necessary training to install manufacture's products per specified requirements. A supplier's willingness to sell its firestopping products to the Contractor or to an Installer engaged by the Contractor does not in itself confer qualification on the buyer.
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- 1.8.2 Installation Responsibility: assign installation of through-penetration fire stop systems and fire-resistive joint systems in Project to a single sole source firestop specialty contractor.
- 1.8.3 The work is to be installed by a contractor with at least one of the following qualifications:
 - 1.8.3.1 FM 4991 approved contractor.
 - 1.8.3.2 UL approved contractor.
 - 1.8.3.3 Manufacturer's accredited fire stop specialty contractor.
- 1.8.4 Installer: Minimum 3 years experience with fire stop installation.

1.9 DELIVERY, STORAGE, AND HANDLING

- 1.9.1 Deliver materials undamaged in manufacturer's clearly labeled, unopened containers, identified with brand, type, and ULC or cUL label where applicable.
- 1.9.2 Coordinate delivery of materials with scheduled installation date to allow minimum storage time at project site.
- 1.9.3 Store materials under cover and protect from weather and damage in compliance with manufacturer's requirements.
- 1.9.4 Comply with recommended procedures, precautions or remedies described in material safety data sheets as applicable.
- 1.9.5 Do not use damaged or expired materials.

1.10 PROJECT CONDITIONS

- 1.10.1 Do not use materials that contain flammable solvents.
- 1.10.2 Scheduling
 - 1.10.2.1 Schedule installation of CAST IN PLACE firestop devices after completion of floor formwork, metal form deck, or composite deck but before placement of concrete.
 - 1.10.2.2 Schedule installation of Drop-In firestop devices after placement of concrete but before installation of the pipe penetration. Diameter of sleeved or cored hole to match the listed system for the device.
 - 1.10.2.3 Schedule installation of other firestopping materials after completion of penetrating item installation but prior to covering or concealing of openings.
- 1.10.3 Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.
- 1.10.4 Weather conditions: Do not proceed with installation of firestop materials when temperatures exceed the manufacturer's recommended limitations for installation printed on product label and product data sheet.
- 1.10.5 During installation, provide masking and drop cloths to prevent firestopping materials from contaminating any adjacent surfaces.

2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- 2.1.1 Provide firestopping composed of components that are compatible with each other, the substrates forming openings, and the items, if any, penetrating the firestopping under conditions of service and application, as demonstrated by the firestopping manufacturer based on testing and field experience.
 - 2.1.2 Provide components for each firestopping system that are needed to install fill material. Use only components specified by the firestopping manufacturer and approved by the qualified testing agency for the designated fire-resistance-rated systems.
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- 2.1.3 Provide a round fire-rated cable management device whenever cables penetrate fire rated walls, where frequent cable changes and additions may occur. The fire-rated cable management device shall consist of a corrugated steel tube with zinc coating, contain an inner plastic housing, intumescent material rings, and inner fabric smoke seal membrane. The length of the sleeve shall be 315 mm (12.4 inches). The fire-rated cable management device shall contain integrated intumescent firestop wrap strip materials sufficient to maintain the hourly rating of the barrier being penetrated. The fire-rated cable management device shall contain a smoke seal fabric membrane or intumescent firestop plugs sufficient to achieve the L-Rating requirements of the barrier type. Install device per the manufacturer's published installation instructions.
- 2.1.4 Penetrations in Horizontal Assemblies: Provide firestopping with ratings determined in accordance with CAN/ULC-S115. For penetrations through a Fire Wall or horizontal Fire Separation provide a firestop system with a "FT" Rating as determined by ULC or cUL which is equal to the fire resistance rating of the construction being penetrated.
- 2.1.5 W-ratings: in accordance with Section 07 84 00.
- 2.1.6 Provide a firestop system with an Assembly Rating as determined by CAN/ULC-S115 which is equal to the time rating of construction joint assembly.
- 2.1.7 Penetrations in Smoke Barriers: Provide firestopping with ratings determined in accordance with CAN/ULC-S115.
 - 2.1.7.1 L-Rating: Not exceeding 5.0 CFM/sqft of penetration opening at both ambient and elevated temperatures.
- 2.1.8 Mold Resistance: Provide penetration firestopping with mold and mildew resistance rating of 0 as determined by ASTM G21.
- 2.1.9 Rain and water resistance: provide perimeter joint sealant tested in accordance with ASTM D 6904 with less than 1 hour tack free time as tested in accordance with ASTM C 679.

2.2 MANUFACTURERS

- 2.2.1 Manufacturer List:
 - 2.2.1.1 AD Fire Protection Systems.
 - 2.2.1.2 Hilti (Canada) Corporation
 - 2.2.1.3 3M.
 - 2.2.1.4 Specified Technologies, Inc. (STI).
 - 2.2.1.5 Tremco, Inc.
- 2.2.2 Substitutions: Where a specific manufacturer is noted in this Section, equivalent products from the manufacturers listed above may be used, subject to compliance with through penetration firestop systems and joint systems listed in the ULC Fire Resistance Directory – Volume III, or UL Products Certified for Canada (cUL) Directory.

2.3 MATERIALS

- 2.3.1 Use only firestop products that have been ULC or cUL tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire-rating involved for each separate instance.
 - 2.3.2 Accessories: provide components for each firestopping and smoke seal systems that are needed to install fill materials. Use only components specified by firestopping material manufacturer, and approved by the qualified testing agency. Accessories include, but are not limited to, the following items:
 - 2.3.2.1 Permanent forming, damming, and backing material.
 - 2.3.2.2 Temporary forming material.
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- 2.3.3 Pre-formed firestop devices for use with non-combustible and combustible pipes (closed and open systems), conduit and/or cable bundles penetrating concrete floors and/or gypsum walls:
 - 2.3.3.1 Hilti Tub Box Kit (CP 681) for use with tub installations.
 - 2.3.3.2 Hilti Cast-In Place Firestop Device (CP 680-PX) for use with XFR pipe.
 - 2.3.3.3 Hilti Cast-In Place Firestop Device (CP 680-M) for use with non-combustible penetrants.
 - 2.3.3.4 Hilti Speed Sleeve (CP 653) for use with cable penetrations.
 - 2.3.3.5 Hilti Firestop Drop-In Device (CFS-DID) for use with non-combustible and combustible penetrants.
 - 2.3.3.6 Hilti Cast-in Firestop sleeve (CFS-CID MD P) and (CFS-CID MD M) for use with combustible and non-combustible pipes through metal deck.
 - 2.3.3.7 Hilti Firestop Block (CFS-BL).
 - 2.3.3.8 STI SpecSeal series SSC Firestop Collars.
 - 2.3.3.9 STI SpecSeal series LCC Firestop Collars.
 - 2.3.4 Sealants or caulking materials for use with non-combustible items including steel pipe, copper pipe, rigid steel conduit and electrical metallic tubing (EMT).
 - 2.3.4.1 Hilti Intumescent Firestop Sealant (FS-ONE MAX).
 - 2.3.4.2 Hilti Fire Foam (CP 620)/CP 660.
 - 2.3.4.3 Hilti Flexible Firestop Sealant (CP 606).
 - 2.3.4.4 Hilti Firestop Silicone Sealant Gun Grade (CFS-S SIL GG).
 - 2.3.4.5 Hilti Firestop Silicone Sealant Self Leveling (CFS-S SIL SL).
 - 2.3.5 Intumescent sealants or caulking materials for use with combustible items (penetrants consumed by high heat and flame) including insulated metal pipe, PVC jacketed, flexible cable or cable bundles and plastic pipe.
 - 2.3.5.1 Hilti Intumescent Firestop Sealant (FS-ONE MAX).
 - 2.3.6 Foams, intumescent sealants, or caulking materials for use with flexible cable or cable bundles.
 - 2.3.6.1 Hilti Intumescent Firestop Sealant (FS-ONE MAX).
 - 2.3.6.2 Hilti Fire Foam (CP 620)/660.
 - 2.3.6.3 Hilti Flexible Firestop Sealant (CP 606).
 - 2.3.6.4 Hilti Firestop Silicone Sealant Gun Grade (CFS-S SIL GG).
 - 2.3.6.5 Hilti Firestop Silicone Sealant Self Leveling (CFS-S SIL SL).
 - 2.3.7 Firestop Putty Pads: Intumescent, non-hardening putty pads to be installed on metallic and non-metallic electrical switch and receptacle boxes to reduce horizontal separation between boxes to less than 610 mm (24 in):
 - 2.3.7.1 STI SpecSeal Series SSP Firestop Putty Pads.
 - 2.3.7.2 Hilti Firestop Putty Pad (CP 617).
 - 2.3.8 Materials used for large size/complex penetrations made to accommodate cable trays, multiple steel and copper pipes, electrical busways in raceways.
 - 2.3.8.1 Hilti Firestop Block (CFS-BL).
 - 2.3.8.2 Hilti Composite Sheet (CFS-COS).
 - 2.3.8.3 Hilti Firestop Mortar (CP 637).
 - 2.3.8.4 Hilti Fire Foam (CP 620)/660.
 - 2.3.8.5 Hilti Firestop Board (CP 675T).
 - 2.3.9 Non-curing, re-penetrable materials used for large size/complex penetrations made to accommodate cable trays, multiple steel and copper pipes, electrical busways in raceways.
 - 2.3.9.1 Hilti Firestop Block (CFS-BL).
 - 2.3.9.2 Hilti Firestop Board (CP 675T).
 - 2.3.10 Re-penetrable, round cable management devices for use with new or existing cable bundles penetrating gypsum or masonry walls.
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- 2.3.10.1 Hilti Speed Sleeve (CP 653) with integrated smoke seal fabric membrane.
- 2.3.10.2 Hilti Firestop Cable Collar (CFS-CC).
- 2.3.10.3 Hilti Firestop Sleeve (CFS-SL SK).
- 2.3.10.4 Hilti Retrofit Sleeve (CFS-SL RK) for use with existing cable bundles.
- 2.3.10.5 Hilti Gangplate (CFS-SL GP) for use with multiple cable management devices.
- 2.3.10.6 Hilti Gangplate Cap (CFS-SL GP CAP) for use at blank openings in gangplate for future penetrations.
- 2.3.11 For blank openings made in fire-rated wall or floor assemblies, where future penetration of pipes, conduits, or cables is expected.
 - 2.3.11.1 Hilti CFS-BL Firestop Block (for walls and floors).
 - 2.3.11.2 Hilti CFS-PL Firestop Plug (for walls and floors).
- 2.3.12 Cast-In-Place Firestop Device: Single component molded firestop device installed on forms prior to concrete placement with totally encapsulated, tamper-proof integral firestop system and smoke sealing gasket. Device shall allow for a concrete floor thickness of minimum 63 mm (2-1/2 in) up to 914 mm (36 in) without the use of field applied extension tubing:
 - 2.3.12.1 STI SpecSeal CID Cast-In Firestop Device.
 - 2.3.12.2 Hilti CP 680 Cast-In Place Firestop Device (for floors only).
- 2.3.13 For single or cable bundles up to 25 mm (1 inch) diameter penetrating gypsum, masonry, concrete walls or wood floor assemblies.
 - 2.3.13.1 Hilti CFS-D Firestop Cable Disc.

3 EXECUTION

3.1 INSTALLERS

- 3.1.1 Labour Use to Install Firestop Systems
 - 3.1.1.1 To ensure complete harmony on the project site, the installation of each scope of work is to be performed jurisdictionally correct per existing trade agreements.

3.2 PREPARATION

- 3.2.1 Verification of Conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
 - 3.2.1.1 Verify penetrations are properly sized and in suitable condition for application of materials.
 - 3.2.1.2 Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, rust, laitance, release agents, water repellents, and any other substances that may affect proper adhesion.
 - 3.2.1.3 Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.
 - 3.2.1.4 Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.
 - 3.2.1.5 Do not proceed until unsatisfactory conditions have been corrected.

3.3 COORDINATION

- 3.3.1 Coordinate construction of openings, penetrations to ensure that the fire stop systems are installed according to specified requirements.
 - 3.3.2 Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration fire stop systems.
 - 3.3.3 Coordinate fire stopping with other trades so that obstructions are not placed in the way prior to the installation of the fire stop systems.
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- 3.3.4 Do not cover up through-penetration fire stop and joint system installations that will become concealed behind other construction until each installation has been examined by the building inspector.

3.4 INSTALLATION

- 3.4.1 Regulatory Requirements: Install firestop materials in accordance with ULC Fire Resistance Directory or UL Products Certified for Canada (cUL) Directory or Omega Point Laboratories Directory.
- 3.4.2 Manufacturer's Instructions: Comply with manufacturer's instructions for installation of through-penetration and construction joint materials.
 - 3.4.2.1 Seal all holes or voids made by penetrations to ensure an air and water-resistant seal.
 - 3.4.2.2 Consult with mechanical engineer, project manager, and damper manufacturer prior to installation of ULC or cUL firestop systems that might hamper the performance of fire dampers as it pertains to duct work.
 - 3.4.2.3 Protect materials from damage on surfaces subjected to traffic.

3.5 FIELD QUALITY CONTROL

- 3.5.1 Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas.
- 3.5.2 Keep areas of work accessible until inspection by applicable code authorities.
- 3.5.3 Inspection of through-penetration firestopping shall be performed in accordance with ASTM E 2174, "Standard Practice for On-Site Inspection of Installed Fire Stops", or other recognized standard.
- 3.5.4 Perform under this section patching and repairing of firestopping caused by cutting or penetrating of existing firestop systems already installed by other trades.
- 3.5.5 Manufacturer's Field Services: During Installation, provide periodic destructive testing inspections to assure proper installation/application. After installation is complete, submit findings in writing indicating whether or not the installation of the tested system identified was installed correctly.

3.6 IDENTIFICATION AND DOCUMENTATION

- 3.6.1 The firestop contractor is to supply documentation for each single application addressed. This documentation is to identify each penetration location on the entire project.
 - 3.6.2 The Documentation Form for through penetrations is to include:
 - 3.6.2.1 A Sequential Location Number.
 - 3.6.2.2 The Project Name.
 - 3.6.2.3 Date of Installation.
 - 3.6.2.4 Detailed description of the penetration location.
 - 3.6.2.5 Tested System or Engineered Judgment Number.
 - 3.6.2.6 Type of assembly penetrated.
 - 3.6.2.7 A detailed description of the size and type of penetrating item.
 - 3.6.2.8 Size of opening.
 - 3.6.2.9 Number of sides of assemblies addressed.
 - 3.6.2.10 Hourly rating to be achieved.
 - 3.6.2.11 Installer's Name.
 - 3.6.3 Copies of these documents are to be provided to the general contractor at the completion of the project.
 - 3.6.4 Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction
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on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:

- 3.6.4.1 The words: "Warning-Through Penetration Firestop System-Do Not Disturb. Notify Building Management of Any Damage."
- 3.6.4.2 Contractor's Name, address, and phone number.
- 3.6.4.3 Through-Penetration firestop system designation of applicable testing and inspecting agency.
- 3.6.4.4 Date of Installation.
- 3.6.4.5 Through-Penetration firestop system manufacturer's name.
- 3.6.4.6 Installer's Name.

3.7 ADJUSTING AND CLEANING

- 3.7.1 Remove equipment, materials, and debris, leaving area in undamaged, clean condition.
- 3.7.2 Clean all surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 This section provides minimum acceptance requirements for vibration isolation for all electrical equipment, conduit, and piping.

1.2 RELATED REQUIREMENTS

- 1.2.1 Concrete work is described in Division 03 and Section 26 05 29.
- 1.2.2 Section 26 22 13 – Low-Voltage Distribution Transformers.
- 1.2.3 Section 26 32 13.16 – Gas-Engine-Driven Generator Sets.

1.3 SUBMITTALS

- 1.3.1 All outdoor mounted equipment shall be restrained for the highest wind speed as specified by the project's structural engineer, the governing building code(s) or the authority having jurisdiction.
- 1.3.2 Submit shop drawings for all devices specified herein and as indicated and scheduled on the drawings. Submittals shall indicate full compliance with the device specification in Part 2. Any deviation shall be specifically noted and subject to engineer approval. Submittals shall include device dimensions, placement, attachment, and anchorage requirements.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Submit a letter from vibration isolation manufacturer to certify correct installation of products, as specified in Part 3 of this Section.

1.5 QUALITY ASSURANCE

- 1.5.1 All vibration isolation systems shall be by one manufacturer.
- 1.5.2 Unless otherwise directed by the local authority having jurisdiction, the following codes and standards will apply:
 - 1.5.2.1 International Building Code 2009.
 - 1.5.2.2 American Society of Civil Engineers 7-05.
 - 1.5.2.3 Ontario Building Code, Latest Edition.
- 1.5.3 Manufacturer's Qualifications: Firms regularly engaged in manufacture of vibration control products of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Vibro-Acoustics.
- 2.1.2 Kinetics Noise Control.
- 2.1.3 BVA Systems.
- 2.1.4 Vibron Limited.
- 2.1.5 Mason Industries.

2.2 VIBRATION ISOLATION

- 2.2.1 Springs: All springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. All springs except internal nested springs shall have an outside diameter not less than 0.8 of the compressed height of the spring. Ends of springs shall be square
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and ground for stability. Laterally stable springs shall have k_x/k_y ratios of at least 0.9. All springs shall be fully colour-coded to indicate capacity – colour striping is not considered adequate.

2.2.2 Corrosion Protection: All springs shall be powder-coated enamel. Housings shall be hot dipped galvanized, powder-coated enamel, or painted with rust-resistant paint.

2.2.3 Isolators:

2.2.3.1 Vibration Isolation Pads: Type N – Neoprene pad type isolators, 10 mm (3/8") minimum thick, ribbed on both sides.

(1) Type NSN – Sandwich neoprene pad type isolators, with 10 mm (3/8") minimum thick ribbed neoprene pads bonded to each side of a 3.5 mm (10 ga) minimum galvanized metal plate. Isolator pads shall be selected to ensure that deflection does not exceed 20% of isolator free height.

2.2.3.2 Rubber-in-Shear Floor Mounts: Type RD – "Double-deflection" neoprene isolators, with neoprene-coated metal surfaces, and top and bottom surfaces ribbed. Isolators shall have bolt holes in the base.

2.2.3.3 Restrained Spring Floor Mounted Isolators: Type CSR – Laterally stable, vertically restrained spring isolators with welded steel housings and heavy top plates for supporting equipment. Springs shall be supported either with a neoprene cup or a metal base plate complete with a ribbed neoprene pad, minimum 6 mm (1/4") thick, bonded to the base plate. Housings shall include vertically restraining limit stops. Minimum clearance around the restraining bolts and between the housing and the spring shall be 13 mm (1/2"). Top plate and restraining bolts shall be out of contact with the housing during normal operation and neoprene grommets shall be incorporated to minimize short-circuiting of restraining bolts. For outdoor applications, housing must be hot-dip galvanized. For indoor applications, powder-coated finish for the housing is acceptable.

3 EXECUTION

3.1 GENERAL

- 3.1.1 Coordinate size, doweling, and reinforcing of concrete equipment housekeeping pads and piers with vibration isolation manufacturer to ensure adequate space and prevent edge breakout failures. Pads and piers must be adequately doweled into structural slab.
- 3.1.2 Coordinate locations and sizes of structural supports with locations of vibration isolators (e.g., roof curbs, cooling towers, air-cooled chillers, etc.).
- 3.1.3 Isolated equipment, duct and piping located on roofs must be attached to the structure. Intermediate supports between the restraint and structure that are not attached to the structure must be approved by the restraint manufacturer.

3.2 VIBRATION ISOLATION

- 3.2.1 Ensure housekeeping pads have adequate space to mount equipment and isolator housings and shall also be large enough to ensure adequate edge distance for isolator anchors.
 - 3.2.2 Select and locate vibration isolation equipment to give uniform loading and deflection, according to weight distribution of equipment.
 - 3.2.3 Engine-generator set silencers and associated exhaust piping shall be supported with Type SHR isolators with a minimum 40 mm (1-1/2 in) static deflection.
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3.2.4 Equipment Isolation:

						Floor Span								
			Slab on Grade			Up to 6 m (20 ft)			6 m to 9 m (20 ft to 30 ft)			9 m to 12 m (30 ft to 40 ft)		
Eqpm Type	HP and Other	RPM	Base Type	Isolator Type	Min. Defl.	Base Type	Isolator Type	Min. Defl., in.	Base Type	Isolator Type	Min. Defl., in.	Base Type	Isolator Type	Min. Defl., in.
Transformers and UPS's														
All	All	All	N/A	NSN	3 mm (0.12")	N/A	NSN	3 mm (0.12")	N/A	NSN	3 mm (0.12")	NM	RD/NSN	6 mm (0.25")
Engine-Driven Generators														
All	All	All	N/A	CSR	19 mm (0.75")	N/A	CSR	38 mm (1.50")	N/A	CSR	64 mm (2.50")	N/A	CSR	89 mm (3.50")
Notes:	(1) Units that are suspended overhead shall use isolation hangers in place of floor mounted isolators with equal or greater deflection.													
	(2) Floor spans are defined as the distance between structural support columns or walls.													

3.2.5 There shall be no rigid contact of isolated equipment with shaft walls, floor slabs, partitions, or non-flexible conduits connections.

3.2.6 Where recommended by the manufacturer, isolator base plates shall be bolted to the structure or foundation. Bolting shall incorporate neoprene bushings and washers.

3.3 SITE TESTS AND INSPECTIONS

3.3.1 After installation, arrange and pay for the vibration isolation product manufacturer, or representative, to visit the site to verify that the vibration isolation systems are installed and operating properly, and shall submit a certificate so stating. Verify that isolators are adjusted, with springs perpendicular to bases or housing, adjustment bolts are tightened up on equipment mountings, and hangers are not cocked.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Provide positive seismic restraints on electrical systems and components required by the building code and by the local authority having jurisdiction.
- 1.1.2 This section covers design, supply, installation, and inspection of complete SFRS (Seismic Force Resisting System) for electrical systems.

1.2 REFERENCES

- 1.2.1 Seismic restraints are to be provided for all electrical and non-structural components of building services in accordance with the current: NBCC; OBC, and good engineering practice (references listed below):
 - 1.2.1.1 CSA S832-14 (R2019), Seismic risk reduction of operation and functional components (OFCs) of buildings.
 - 1.2.1.2 SMACNA (Sheet Metal and Air-conditioning Contractors' National Association's) Seismic Restraint Manual Guidelines for Mechanical Systems (3rd ed.).
 - 1.2.1.3 ASHRAE (American Society for Heating, Refrigerating and Air-conditioning Engineers) A Practical Guide to Seismic Restraint; ASHRAE Applications Handbook, Seismic and Wind Restraint Design Chapter; ASHRAE Standard 171-2008: Methods of Test for Seismic restraints.
 - 1.2.1.4 VISCMA (The Vibration Isolation and Seismic Control Manufacturers Association) has developed Testing and Rating Standards for Seismic Restraint Components that comply with Code and ASHRAE based requirements.
- 1.2.2 The following guides may be used for supplemental information on typical seismic installation practices. Where a conflict exists between the guides and these construction documents, the construction documents will preside.
 - 1.2.2.1 Federal Emergency Management Agency (FEMA) manual 413, Installing Seismic Restraints for Electrical Equipment, January 2014.

1.3 COORDINATION

- 1.3.1 Trades shall supply necessary information to the Vibration Isolation Manufacturer regarding equipment to be isolated.
- 1.3.2 Provide shop drawings to other trades for setting anchor bolts and other appurtenances necessary for the proper installation of this equipment.

1.4 SUBMITTALS

- 1.4.1 Shop Drawings:
 - 1.4.1.1 Include placement drawings for electrical equipment and equipment assemblies including runs of cable trays and conduit/cable racks showing methods of attachment to particular structure for each piece of equipment and assembly and provide anchorage/attachment details. Submit samples of materials required to complete seismic restraint work for review if and when required.
- 1.4.2 Product Data:
 - 1.4.2.1 Include Seismic Rating Data for each seismically rated isolator or restraint component.
 - 1.4.2.2 Submit copies of documents requested herein, testing reports, certificate of approvals, and commissioning sheets.
- 1.4.3 Delegated Design Submittals:
 - 1.4.3.1 Submit for Consultant's review, seismic design drawings and product shop drawings with calculations approved and sealed by a Professional Engineer

licensed and registered in Place of Work and experienced in such Work. Be responsible for costs for services of this Professional Engineer. Shop drawings to identify equipment type, manufacturer's name, model number and weight of equipment to be restrained.

- 1.4.3.2 Include for manufacturer of vibration control products, to develop/design a seismic restraint system and perform seismic calculations in accordance with latest requirements of local governing building code, requirements of local governing authority having jurisdiction, and additional requirements specified in this article. Design of seismic restraints to include requirements to withstand forces of area rating as per local governing building code requirements.
- 1.4.3.3 Provide calculations to determine restraint loadings for all restrained systems and equipment resulting from seismic forces.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Include for Professional Engineer to inspect same on site (note that multiple inspections to be required as work progresses) and to provide typewritten Inspection Reports to the Consultant throughout construction and to provide "Letters of Assurance and Conformance" with specified Codes, Standards and Bylaws. Additionally, include copies of documents in Operating and Maintenance Manuals.
- 1.5.2 At the completion of the project, upon request by the Consultant, attend a review of the installation on site.
- 1.5.3 Provide a sealed written report, certifying that the installations have been completed in accordance with the specified design(s) and shop drawing(s) can be furnished, by others, upon this request.
- 1.5.4 The installing contractor shall submit a report to the Consultant, including the manufacturer's representative's final report, indicating that all seismic restraint material has been properly installed, or steps that are to be taken by the Contractor to properly complete the seismic restraint work as per the specifications.
- 1.5.5 Record documents: documented torques.

1.6 QUALITY ASSURANCE

- 1.6.1 The contractor shall utilize a supplier familiar/experienced with the design of seismic systems to provide a comprehensive package of isolation and seismic restraint for the project. Provide detailed shop drawings showing the proposed restraint system for all required equipment, piping, and ductwork on the project. The shop drawings shall include calculations certified by a Professional Engineer (Structural), licensed in the jurisdiction where the project occurs.
- 1.6.2 Certification documents to be signed and sealed by a Professional Engineer (Structural) with at least 5 years experience in the design of seismic restraints.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Manufacturer List:
 - 2.1.1.1 Eaton TOLCO.
 - 2.1.1.2 Mason Industries.
 - 2.1.1.3 Kinetics Noise Control.
 - 2.1.1.4 nVent (Caddy).
 - 2.1.1.5 Vibro-Acoustics.
 - 2.1.2 Substitutions: Other manufacturers acceptable to the Authority Having Jurisdiction.
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2.2 DESIGN CRITERIA

- 2.2.1 Review architectural and structural drawings to confirm the seismic criteria for the project.

2.3 GENERAL

- 2.3.1 Electrical equipment installation is to meet local governing authority having jurisdiction and code seismic requirements and additional requirements for vibration isolation.
- 2.3.2 Provide labour, materials, and equipment required and necessary to seismically restrain electrical equipment and equipment bases including concrete pads, and guarantee function of materials and equipment supplied.
- 2.3.3 Provide additional seismic requirements for suspended electrical raceways, luminaires, and other equipment as per governing local authority requirements and requirements of current codes and by-laws.
- 2.3.4 Provide seismic restraining devices to restrain mechanical, electrical, and related equipment, and equipment bases including concrete pads, as per governing local authority requirements and requirements of current codes and by-laws.
- 2.3.5 In event that inadequate isolation is provided by isolation product manufacturer's isolation package, be responsible for improving isolation to an acceptable standard at no additional cost to contract. Isolation product manufacturer's seismic restraint engineer to verify that seismic restraints and combination isolator/restraints intended for use on project are fit for intended purpose. Be responsible for ensuring that manufacturer's seismic restraints are in compliance with applicable local building code requirements for Place of Work.

2.4 VIBRATION CONTROLS AND SEISMIC RESTRAINTS

- 2.4.1 Electrical equipment installation is to meet local governing authority having jurisdiction and code seismic requirements and additional requirements outlined herein.
 - 2.4.2 Provide labour, materials, and equipment required and necessary to seismically restrain electrical equipment and equipment bases including concrete pads, and guarantee function of materials and equipment supplied.
 - 2.4.3 Make electrical connections to vibration-isolated equipment with flexible conduit or other flexible means acceptable to the Consultant and local governing authority having jurisdiction so as not to restrict maximum anticipated movement of equipment under seismic excitation movement.
 - 2.4.4 In event that inadequate isolation is provided by isolation product manufacturer's isolation package, be responsible for improving isolation to an acceptable standard at no additional cost to contract. Isolation product manufacturer's seismic restraint engineer to verify that seismic restraints and combination isolator/restraints intended for use on project are fit for intended purpose. Be responsible for ensuring that manufacturer's seismic restraints are in compliance with applicable local building code requirements for Place of Work.
 - 2.4.5 Provide additional seismic requirements for suspended electrical raceways, luminaires, and other equipment as per governing local authority requirements and requirements of current codes and by-laws.
 - 2.4.6 Include for manufacturer of vibration control products to develop/design a seismic restraint system and perform seismic calculations in accordance with latest requirements of local governing building code, requirements of local governing authority having jurisdiction, and additional requirements specified in this article. Design of seismic restraints to include provisions to withstand forces of area rating as per governing building code requirements.
 - 2.4.7 Provide vibration isolation for equipment or parts connected rigidly to isolated equipment.
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- 2.4.8 Provide vibration isolation for transformers by means of bridge bearing neoprene isolators or open steel spring isolators. Static deflection of vibration isolators for electrical transformers is indicated below. Isolators requiring a static deflection greater than 13 mm (1/2") to be open spring isolators unless otherwise specified.

<u>Transformer Rating</u>	<u>On Grade (Isolated Slab)</u>	<u>Location on Grade (Continuous Slab)</u>	<u>Upper Floor (Suspended Slab)</u>
Less than 10 kVA	6 mm	6 mm	18 mm
10 – 100 kVA	6 mm	12 mm	25 mm
Greater than 100 kVA	6 mm	25 mm	38 mm

- 2.4.9 Standard vibration isolation requirements of equipment such as gensets, power transformers and distribution equipment, to comply with following:
- 2.4.9.1 Choose equipment isolation mounts on basis of achieving 98% vibration isolation efficiency at lowest operating speed. Natural frequency of each vibration isolation system to be at least 1/10 of lowest excitation frequency of rotating machinery, whenever practicable, but in no case less than 1/7. Where structural floor deflection exceeds 1/10 of determined static deflection of isolator, increase isolator static deflection to maintain this minimum ratio of floor to isolator deflection. Where static deflections are shown on drawings, Specifications, or schedules, they are to be used as a guide only. Actual isolators are to achieve required static deflection under load, with at least 50% reserve deflection;
- 2.4.9.2 Submit shop drawings identifying equipment, lowest operating speed, weight, brand, type and location of isolators prior to ordering or fabrication.
- 2.4.10 Neoprene Isolators:
- 2.4.10.1 Neoprene isolators to be bridge bearing rated type manufactured from bridge bearing quality neoprene, CAN/CSA-S6-88 Section 11.5.8.
- 2.4.10.2 Where a ribbed pad is used, height of ribs is not to exceed 0.7 times width of rib. A steel layer to be used to distribute load in a multi-layered unit.
- 2.4.10.3 Select neoprene pads or elements at supplier's optimum recommended loading and do not load beyond limit specified in neoprene manufacturer's literature.
- 2.4.10.4 Test neoprene isolators to ASTM specifications. Submit to Consultant, following test data to verify performance of neoprene isolators:
- (1) A data sheet listing all of ASTM test results.
 - (2) Load deflection curves for isolator indicating deflection to full compression for both laterally restrained and unrestrained isolators.
- 2.4.11 Open Steel Spring Isolators:
- 2.4.11.1 Springs to be "Iso-Stiff" (spring coefficient 1.0 to 1.5) with a working deflection between 0.3 and 0.6 of solid deflection.
- 2.4.11.2 Spring mounts to be complete with levelling devices, minimum 6 mm (1/4") thick neoprene sound pads, and zinc chromate plated hardware.
- 2.4.11.3 Sound pads to be sized for a minimum deflection of 1.2 mm (0.0472") and meet requirements for neoprene isolators.
- 2.4.12 Seismic restraints to restrain equipment in all directions and to be sized to meet appropriate Sp factor defined in Table 4.1.9.D of current National Building Code and Commentary J of Supplement to current Code. Calculations bearing seal of a qualified Professional Engineer to be submitted with shop drawings to justify stated seismic restraint requirements.
- 2.4.13 Attachment points and fasteners to be capable of withstanding a load of 3 times sized capacity of restraint. Equipment suppliers to provide proof of conformance with this clause by means of shop drawings certified by a qualified Professional Engineer.

- 2.4.14 Submit test data to the Consultant, showing load deflection curves up to 1.5 times rated capacity of restraint, and certifying that neither neoprene elements nor restraint body sustained any deformation after release of load.
- 2.4.15 Adjust restraints to have clearances between 3 mm (1/8") and 6 mm (1/4") under normal operating conditions of equipment.

2.5 SEISMIC RESTRAINTS FOR CONTAINERIZED GENSETS

- 2.5.1 Electrical equipment installed inside containerized genset enclosure specified in Section 26 32 13.16 to comply with local governing authority and code seismic requirements and additional requirements outlined herein.
- 2.5.2 Supply labour, materials, and equipment required and necessary to seismically restrain electrical equipment and guarantee function of materials and equipment supplied.
- 2.5.3 Neoprene Isolators:
 - 2.5.3.1 Neoprene isolators to be bridge bearing rated type manufactured from bridge bearing quality neoprene, CAN/CSA-S6-88 Section 11.5.8.
 - 2.5.3.2 Where a ribbed pad is used, height of ribs is not to exceed 0.7 times width of rib. A steel layer to be used to distribute load in a multi-layered unit.
 - 2.5.3.3 Select neoprene pads or elements at supplier's optimum recommended loading and do not load beyond limit specified in neoprene manufacturer's literature.
 - 2.5.3.4 Test neoprene isolators to ASTM specifications. Submit to the Consultant, following test data to verify performance of neoprene isolators:
 - (1) a data sheet listing ASTM test results;
 - (2) load deflection curves for isolator indicating deflection to full compression for both laterally restrained and unrestrained isolators.
- 2.5.4 Open Steel Spring Isolators:
 - 2.5.4.1 Springs to be "Iso-Stiff" type with spring coefficient from 1.0 to 1.5.
 - 2.5.4.2 Spring mounts to be complete with levelling devices, minimum 6 mm (1/4") thick neoprene sound pads.
- 2.5.5 Seismic restraints to restrain equipment in all directions and to be sized to meet appropriate Sp factor defined in Table 4.1.9.D of current National Building Code and Commentary J of Supplement to current Code. Calculations bearing seal of a qualified Professional Engineer to be submitted with shop drawings to justify stated seismic restraint requirements.
- 2.5.6 Attachment points and fasteners to be capable of withstanding a load of 3 times sized capacity of restraint. Equipment suppliers to provide proof of conformance with this clause by means of shop drawings certified by a qualified Professional Engineer.
- 2.5.7 Submit test data to the Consultant, showing load deflection curves up to 1.5 times rated capacity of restraint, and certifying that neither neoprene elements nor restraint body sustained any deformation after release of load.
- 2.5.8 Adjust restraints to have clearances between 3 mm and 6 mm (1/8" and 1/4") under normal operating conditions of equipment.

3 EXECUTION

3.1 GENERAL

- 3.1.1 The following typical electrical equipment requires seismic protection (as applicable to Project):
 - 3.1.1.1 Transformers;
 - 3.1.1.2 Switchboards/switchgear;
 - 3.1.1.3 Panelboards;
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- 3.1.1.4 Engine/generator and generator control panel;
- 3.1.1.5 Automatic transfer switches;
- 3.1.1.6 Fire alarm system, cabinets and devices;
- 3.1.1.7 Luminaires;
- 3.1.1.8 Mobile generator connection box;
- 3.1.1.9 Conduit and duct banks;
- 3.1.1.10 Genset PLC system and cabinet;
- 3.1.1.11 Other electrical equipment, as required.

3.2 PREPARATION

- 3.2.1 The Contractor shall notify the local representative of the seismic restraint materials manufacturer prior to installing any seismic restraint devices. The Contractor shall seek the representative's guidance in any installation procedures with which he/she is unfamiliar.
- 3.2.2 Obtain required training from manufacturer's representative on any special installation procedures. Install components in accordance with manufacturer's instructions to suit specific installation requirements.
- 3.2.3 Coordinate size, shape, reinforcement, and attachment of all housekeeping pads supporting vibration/seismically rated equipment. Concrete shall have a minimum compressive strength of 20 kPa (3,000 psi) or as specified by the Consultant. Coordinate size, thickness, doweling, and reinforcing of concrete equipment housekeeping pads and piers with vibration isolation and seismic restraint device manufacturer to ensure adequate space, embedment and prevent edge breakout failures. Pads and piers must be adequately doweled into structural slab.
- 3.2.4 Housekeeping Pads must be adequately reinforced and adequately sized for proper installation of equipment anchors. Refer seismic restraint manufacturer's written instructions.
- 3.2.5 Coordinate with vibration/seismic restraint manufacturer and the structural engineer of record to locate and size structural supports underneath vibration/seismically restrained equipment (e.g., roof curbs, cooling towers and other similar equipment). Installation of all seismic restraint materials specified in this section shall be accomplished as per the manufacturer's written instructions. Adjust isolators and restraints after piping systems have been filled and equipment is at its operating weight, following the manufacturer's written instructions.

3.3 INSTALLATION

- 3.3.1 Isolated and restrained equipment, conduit located on roofs must be attached to the structure. Supports (e.g., sleepers) that are not attached to the structure are not acceptable.
- 3.3.2 Attach conduit to the trapeze per seismic restraint manufacturer's design. Install cables so they do not bend across sharp edges of adjacent equipment or building structures.
- 3.3.3 Do not brace or support equipment to separate portions of the structure that may act differently in response to an earthquake. For example, do not connect a transverse restraint to a wall, and then a longitudinal restraint to either a floor/ceiling/roof at the same braced location.
- 3.3.4 Install vertical braces to stiffen hanger rods and prevent buckling per seismic restraint manufacturer's design. Clamp vertical brace to hanger rods. Requirements apply equally to hanging equipment. Do not weld vertical braces to hanger rods.
- 3.3.5 General Seismic Controls for Electrical Systems:
 - 3.3.5.1 Seismically restrain per specific code requirements all Electrical components listed below (unless otherwise indicated on the drawings), using seismic cable restraints:

- (1) Seismically restrain all conduit 78 mm (3") in nominal diameter and larger. Single supported conduit is restrained in the same fashion as single clevis supported pipe.
 - (2) Seismically restrain all conduit, bus ducts, or cable trays that are supported on trapeze bars, that have been assigned a Component Importance Factor equal to 1.5, and that have a total weight greater than 146 N/m (10 lb/ft). This total weight includes not only the conduit, bus duct, or cable trays, but also includes the trapeze bars as well.
- 3.3.5.2 The Contractor is to provide the weight per unit length for cable trays and bus duct.
 - 3.3.5.3 Single supported conduit and trapeze supported conduit, bus duct, and cable trays to be seismically restrained in a manner similar to mechanical pipes and HVAC ducts.
 - 3.3.5.4 Provide seismic restraint components intended to be used with suspended single supported conduit and trapeze supported conduit, cable trays, and bus ducts. Components intended to both support and restrain distribution systems such as wall mounted conduit, cable trays, and bus ducts will need to be designed and evaluated for both the dead weight load and the design horizontal seismic load.
 - 3.3.5.5 To ensure that the seismic forces are transferred properly to the restraint points, cables should be strapped either individually or in bundles to the cable tray at regular intervals. It is necessary for the conduit, bus ducts, and cable trays to be attached to the trapeze bars sufficiently to resist the design horizontal seismic forces, both transverse (T) and longitudinal (L).
 - 3.3.5.6 Brace a change of direction longer than 3.7 m (12 ft).
 - 3.3.5.7 This specification does not allow the use of the "12 inch rule" where the piping and electrical may be exempted from seismic restraint based on the length of the support rods provided that the rods are not subjected to bending moments.
 - 3.3.5.8 Install restraint cables so they do not bend across edges of adjacent equipment or building structure. Tie back to structure at 45 degrees to the structure.
 - 3.3.5.9 Longitudinal restraints for single pipe supports shall be attached rigidly to the pipe, not to the pipe hanger.
 - 3.3.5.10 For supports with multiple pipes (trapezes), secure pipes to trapeze member with clamps approved for application.
 - 3.3.5.11 Install flexible metal hose loops in piping which crosses building seismic joints, sized for the anticipated amount of movement.
 - 3.3.5.12 Install flexible piping connectors where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.
 - 3.3.5.13 Roof mounted duct is to be installed on sleepers or frames mechanically connected to the building structure. Roof anchors and seismic cables or frames shall be used to resist seismic and wind loading. Wind loading factors shall be determined by the registered design professional.
 - 3.3.5.14 Longitudinal restraints for single conduit supports shall be attached rigidly to the pipe, not to the pipe/conduit hanger.
 - 3.3.5.15 For supports with multiple conduits (trapezes), secure conduit to trapeze member with clamps approved for application.
 - 3.3.5.16 Rod Stiffener Clamps are required where the hanger rod exceeds the maximum length shown in the seismic calculation sheets. They are only required at restraint locations.
 - 3.3.5.17 Seismically Rated Beam Clamps are required where welding to or penetrations to steel beams are not approved.
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- 3.3.5.18 Adjust restraint cables so that they are not visibly slack. Cable not to support weight during normal operation.
- 3.3.5.19 Seismic systems are to be compatible with requirements for anchoring and guiding of systems.
- 3.3.5.20 Drilled or power-driven anchors or fasteners shall not be permitted for use with seismic control measures.
- 3.3.5.21 Friction due to gravity does not constitute a seismic attachment.
- 3.3.5.22 Seismic restraint connections are not to be connected to the bottom chord of steel joists or the bottom flange of steel beams.
- 3.3.5.23 Standard beam clamps can be used to support restrained components; they cannot be used to connect the seismic restraint to the structure – only for the hanger rods.
- 3.3.5.24 Make electrical connections to vibration-isolated equipment with flexible conduit or other flexible means acceptable to the Consultant and local governing authority having jurisdiction so as not to restrict maximum anticipated movement of equipment under seismic excitation movement.
- 3.3.6 Panelboards, Lighting, Emergency Lighting Battery Units, and Emergency Remote Heads
 - 3.3.6.1 Wall mounted panelboards, lighting, emergency lighting battery units, and emergency remote heads can be directly mounted to the building structure with approved fasteners to suit. Minimum two or more anchors shall be provided on each side of all wall mounted equipment.
 - 3.3.6.2 For emergency battery units, pre-installed brackets must be used.

3.4 FIELD TESTS AND INSPECTIONS

- 3.4.1 Test, adjust, and certify installation. Submit copies of test report to the Consultant.
- 3.4.2 Inspect for removal of break away hardware to ensure proper torques of installed systems.
- 3.4.3 For non-visually verifiable product, manufacturers to verify proper torque for a minimum 10% of application. Document torques for applications per manufacturer's instructions.
- 3.4.4 The contractor shall notify the local representative of the seismic restraint materials manufacturer mid-way through the listed project if they require an inspection of any and all vibration and seismic restraint devices already installed. A typewritten report of any installation errors, improperly selected devices, or other fault in the system which could affect the performance of the system shall be documented and the contractor shall perform all steps that are required from this written report to properly complete the vibration and seismic restraint work as per the specifications. Report to include clear sketches as required.
- 3.4.5 The installing contractor shall submit a report to the Consultant, including the manufacturer's representative's final report, indicating that all seismic restraint material has been properly installed, or steps that are to be taken by the contractor to properly complete the seismic restraint work as per the specifications.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Nameplates and labels.
- 1.1.2 Wire and cable markers.
- 1.1.3 Conduit markers.
- 1.1.4 Receptacle labels.
- 1.1.5 Signage.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 09 91 00 – Painting.
- 1.2.2 Section 27 05 53 – Identification for Communications Systems.

1.3 SUBMITTALS

- 1.3.1 Product Data: Provide catalogue data for nameplates, labels, and markers.
- 1.3.2 Provide shop drawings of nameplates for Consultant's review prior to fabrication (scale 1:1).
- 1.3.3 Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

1.4 REGULATORY REQUIREMENTS

- 1.4.1 Provide products listed and classified by CSA Group as suitable for the purpose specified and indicated.

2 PRODUCTS

2.1 NAMEPLATES AND LABELS

- 2.1.1 Nameplates:
 - 2.1.1.1 Engraved three-layer laminated plastic, letters on contrasting background.
 - 2.1.1.2 Colours to match existing building system, where applicable. If no building system exists, use the following:
 - (1) 347/600 volt system: White text on Blue background.
 - (2) 120/208 volt system: Black text on White background.
 - (3) Fire Detection system: White text on Red background.
 - (4) Emergency Lighting system: Red text on White background.
 - (5) LV systems: White text on Green background.
 - (6) 120/208 volt Uninterruptable Power Supply (UPS): White text on Orange background.
 - 2.1.1.3 Confirm colours with the Consultant prior to ordering nameplates.
- 2.1.2 Equipment Nameplates to indicate:
 - 2.1.2.1 Equipment/Panelboard ID
 - 2.1.2.2 Ampacity.
 - 2.1.2.3 Voltage
 - 2.1.2.4 Number of Phases

- 2.1.2.5 Number of wires in system
- 2.1.2.6 Interrupting Capacity
- 2.1.2.7 Size, number of poles, Panelboard ID, and circuit number of upstream overcurrent protection device.
 - (1) Location of upstream device if not in the same room.
- 2.1.3 Coordination Study Labels to Section 26 05 73.16.
- 2.1.4 Arc Flash Study Labels to Section 26 05 73.19.
- 2.1.5 Locations:
 - 2.1.5.1 Distribution panelboards, and individual distribution panelboard branch breakers.
 - 2.1.5.2 Receptacle panelboards.
 - 2.1.5.3 Each electrical distribution and control equipment enclosure.
 - 2.1.5.4 Uninterruptible Power Supply.
 - 2.1.5.5 Mechanical Equipment.
 - 2.1.5.6 UPS receptacles.
 - 2.1.5.7 Disconnects, starters and contactors: indicate equipment being controlled and voltage.
 - 2.1.5.8 Terminal cabinets, junction boxes, and pull boxes: indicate system and voltage.
 - 2.1.5.9 Transformers: indicate capacity, primary and secondary voltages.
- 2.1.6 Letter Size:
 - 2.1.6.1 Use 3 mm letters for identifying individual equipment and loads.
 - 2.1.6.2 Use 6 mm letters for identifying grouped equipment and loads.
- 2.1.7 Labels:
 - 2.1.7.1 Mechanically fastened with sheet metal screws, with 5 mm white letters on black background.
 - 2.1.7.2 White letters on red background for UPS and equipment, and devices downstream of UPS.
 - 2.1.7.3 Labels: embossed plastic labels with 6 mm high letters unless specified otherwise.
 - 2.1.7.4 Wording on nameplates and labels to be reviewed by the Consultant prior to manufacturing.
 - 2.1.7.5 Allow for minimum of twenty-five (25) letters per nameplate and label.
 - 2.1.7.6 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
 - 2.1.7.7 Terminal cabinets and pull boxes: indicate system and voltage.

2.2 WIRING IDENTIFICATION

- 2.2.1 Identify wiring with permanent indelible identifying markings, numbered, on both ends of phase conductors of feeders and branch circuit wiring.
- 2.2.2 Maintain phase sequence and colour coding throughout.
- 2.2.3 Colour coding: to CSA C22.1.
- 2.2.4 Use colour coded wires in communication cables, matched throughout system.

2.3 WIRE MARKERS

- 2.3.1 Description: tape, split sleeve, or tubing type wire markers.
 - 2.3.2 Locations: Each conductor at panelboard gutters, pull boxes, outlet and junction boxes and each load connection.
 - 2.3.3 Legend:
 - 2.3.3.1 Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
 - 2.3.3.2 Control Circuits: Control wire number indicated on shop drawings.
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2.4 CONDUIT AND BOX MARKERS

- 2.4.1 Colour code conduits, boxes, and metallic sheathed cables.
- 2.4.2 Location: Provide markers for each conduit longer than 2 m.
- 2.4.3 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 15 m intervals.
- 2.4.4 Colours to match equipment nameplate background colour:
 - 2.4.4.1 347/600 volt system: Blue.
 - 2.4.4.2 120/208 volt system: Black.
 - 2.4.4.3 Fire Alarm system: Red.
 - 2.4.4.4 Emergency Lighting system: Red/White.
 - 2.4.4.5 LV Systems (EPO, Remote Monitoring, Generator Control, Communications): Green.
 - 2.4.4.6 120/208 volt Uninterruptable Power Supply (UPS): Orange
- 2.4.5 Confirm colours with the Consultant prior to commencing rough-in.

2.5 JUNCTION AND PULL BOXES

- 2.5.1 Clearly identify main pull or junction boxes (excluding obvious outlet boxes) by painting outside of covers.
- 2.5.2 Spray painting: not permitted.
- 2.5.3 Paint colours to be in accordance with following schedule:
 - 2.5.3.1 Lighting: yellow.
 - 2.5.3.2 Normal power: blue.
 - 2.5.3.3 Emergency power: orange.
 - 2.5.3.4 Fire alarm: red.
 - 2.5.3.5 Communications systems including telephone and data: green.
 - 2.5.3.6 Miscellaneous signals: brown.
- 2.5.4 In addition to painting miscellaneous signal boxes, clearly identify specific system in which box is installed. Identify source panelboard for power circuits.

2.6 BRANCH BREAKER LABELS

- 2.6.1 General:
 - 2.6.1.1 Legibly identify every circuit and circuit modification as to its clear, evident, and specific purpose or use. Include sufficient detail to allow each circuit to be distinguished from all others.
 - 2.6.1.2 Label spare positions that contain unused overcurrent devices or switches.
 - 2.6.1.3 Do not describe any circuit in a manner that depends on transient conditions of occupancy.
- 2.6.2 Switchboards, distribution panelboards, enclosed breakers, and disconnect switches:
 - 2.6.2.1 Locate identification at each switch.
 - 2.6.2.2 Branch breaker nameplates on switchboards, distribution panelboards and switchboards, and generator load breakers to indicate:
 - (1) Locate identification at each switch on a switchboard.
 - (2) Identification of downstream equipment fed from the breaker.
 - (A) Location of downstream device if not in the same room.
 - (3) Breaker size and number of poles.
 - (4) Interrupting Capacity.
 - (5) Circuit number (where applicable).

- (6) Do not describe any circuit in a manner that depends on transient conditions of occupancy.

2.6.3 Lighting and Receptacle Panelboards:

- 2.6.3.1 Provide a circuit directory that is located on the face or inside of the panel door.
- 2.6.3.2 Do not describe any circuit in a manner that depends on transient conditions of occupancy.

2.7 RECEPTACLE LABELS

- 2.7.1 Label all receptacles with the panelboard ID and circuit number.
- 2.7.2 Use receptacle labels by electronic labeller Brother P-Touch, model PT-20/25, Dymo-Tape or approved equal.
- 2.7.3 Location: On receptacle wall plate.

3 EXECUTION

3.1 EQUIPMENT NAMEPLATES FROM MANUFACTURERS

- 3.1.1 Ensure manufacturer's nameplates, CSA labels and identification nameplates are visible and legible after equipment is installed.
- 3.1.2 Manufacturers' nameplates and CSA labels are to be visible and legible after equipment is installed. Provide warning signs, as specified, or to meet requirements of Inspection Department, Health and Safety, and the Consultant.
- 3.1.3 Label power outlets with circuit identification on visible portion of faceplate or surface mounted outlet box.

3.2 CONDUIT AND BOX IDENTIFICATION

- 3.2.1 Locate labels as follows:
 - 3.2.1.1 At every end of every conduit, duct, or cable run, adjacent to item of equipment serviced.
 - 3.2.1.2 On each exposed conduit, duct or cable passing through a wall, partition, or floor (one on each side of such wall partition or floor).
 - 3.2.1.3 At intervals of 15 m (50 ft) along every exposed conduit, duct or cable run exceeding 15 m (50 ft) in length.
 - 3.2.1.4 At every access point on concealed conduit duct or cable.
 - 3.2.1.5 At each junction box.
- 3.2.2 Place labels so as to be visible from 1500 mm (5 ft) above adjacent floor platform.

3.3 PREPARATION

- 3.3.1 Degrease and clean surfaces to receive nameplates and labels.

3.4 APPLICATION

- 3.4.1 Confirm colours prior to start of work.
 - 3.4.2 Install nameplate and label parallel to equipment lines.
 - 3.4.3 Secure nameplate to equipment front using adhesive.
 - 3.4.4 Secure nameplate to inside surface of door on panelboard that is recessed in finished locations.
 - 3.4.5 Identify conduit using field painting.
 - 3.4.6 Paint coloured band on each conduit longer than 2 m.
 - 3.4.7 Paint bands 6 m on centre.
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3.5 LABELLING

- 3.5.1 Colour code wiring consistently throughout the installation and generally match colour coding of internal wiring of pre-wired components.
- 3.5.2 Label wiring with point name using Thomas & Betts 12 character polestar metalized labels with 3 rows of characters per label, or equal by Brady. Label to occur as a minimum at both ends and at pull boxes of the wiring run.
- 3.5.3 Identify all pull boxes, junction boxes, etc. (installed as part of this project or used by this project) with the exact use of the box. Indelible felt pen marker is acceptable.
- 3.5.4 Label light control items with point name using Thomas & Betts 12 character label, or equal by Brady. Label to be black lettering on clear backing.
- 3.5.5 Label relays and controllers inside panels using Thomas & Betts 12 character label, or equal by Brady.
- 3.5.6 Provide red, 13 mm (1/2 in) diameter, sticker on emergency light fixture frame. Include circuit number on sticker with thin permanent black mark pen.

3.6 LABELS AND SIGNS

- 3.6.1 Manufacturers' nameplates and CSA labels are to be visible and legible after equipment is installed. Provide warning signs, as specified, or to meet requirements of Inspection Department, Health and Safety, and the Consultant.
- 3.6.2 Label power outlets with circuit identification on visible portion of faceplate or surface mounted outlet box.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Provide a short circuit and coordination study for the new portions of electrical distribution system. The basic analysis shall include a protective device evaluation, and a protective device coordination study.
- 1.1.2 The project shall begin at the point of utility service for the facility and continue down through the system to all downstream distribution and branch panelboards, motor control centres and significant motor locations.
- 1.1.3 The project shall include any new generators and any associated emergency power distribution equipment, including automatic transfer switches and generator ground fault protection.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 73.19 – Arc-Flash Hazard Analysis.
- 1.2.2 Single Line Diagram.

1.3 REFERENCE STANDARDS

- 1.3.1 Perform all studies in accordance with the latest applicable IEEE and ANSI standards.
 - 1.3.1.1 ANSI C38.010-1999.
 - 1.3.1.2 ANSI C37.5-1979.
 - 1.3.1.3 ANSI C37.13-1990.

1.4 SUBMITTALS

- 1.4.1 In accordance with Section 01 33 00:
- 1.4.2 Submit the following:
 - 1.4.2.1 Submit for review three copies of the protection coordination study.
 - 1.4.2.2 Shop drawings for equipment affected by the coordination study will not be reviewed until the coordination study has been submitted and reviewed.
 - 1.4.2.3 Include a one-line diagram of the system.
 - 1.4.2.4 Bind the final report in a three-ring binder, as well as a soft copy.
- 1.4.3 Projection System Coordination:
 - 1.4.3.1 Prepare a graph or coordination curves, prior to manufacture of service entrance and distribution equipment on K & E No. 336E Time-Current characteristic graph paper. Time-current characteristics shall be plotted of the following:
 - (1) Supply Authorities relays or fuses protecting incoming service (Contractor under this section shall obtain this information).
 - (2) Main and feeder protective devices at every voltage level used in distribution system.
 - (3) Protective devices associated with largest motor and/or refrigeration compressor.
 - 1.4.3.2 Preliminary submission of graph for comment will be accepted. Submit graph to Supply Authority for approval by them as providing satisfactory co-ordination. When curves have been approved by Supply Authority, they shall be submitted for approval. After approval has been obtained, order protective devices, and calibrate to conform with these curves.
 - 1.4.3.3 Each time-current characteristic curve sheet shall include:
 - (1) A single line diagram for the portion of the system involved.

- (2) Transformer damage curves (where applicable).
 - (3) Cable damage curves (where applicable).
 - (4) Available fault levels for the portion of the system involved.
- 1.4.3.4 Consult manufacturer of the refrigeration compressors and obtain recommendations for settings on starters. Incorporate information in co-ordination curves and submit the associated curves to Compressor Manufacturer and obtain approval from the manufacturer.
- 1.4.3.5 Compressor manufacturer and mechanical trade contractor will determine and calibrate proper protection on motor starters and will ensure that it coordinates with protective devices on switchboard.
- 1.4.3.6 Co-ordination curves, mentioned above, shall be prepared by distribution equipment manufacturers as soon as possible after award of contract.
- 1.4.3.7 At the option of this contractor under this section, these co-ordination curves may also be prepared by an independent testing organization. In this case, the independent testing organization shall determine the proper settings of all protective relays and devices and pass them on to the switchboard manufacturer for incorporation into the switchboards. Include all associated costs in the tender.
- 1.4.3.8 Distribution Equipment manufacturers shall examine drawings and specifications prior to award of contract to ensure that relays and devices being supplied by them will co-ordinate satisfactorily to Supply Authority requirements. Payment will not be allowed, after award of contract, for extra charges due to device changes to comply with recommended practices, due to oversight or negligence by distribution equipment manufacturers.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 The Engineer who prepared the report shall visit the site and confirm that the feeder sizes as installed are consistent with the report as submitted.
- 1.5.2 Submit final version of the report with as-constructed feeder lengths and feeder sizes.

1.6 QUALITY ASSURANCE

- 1.6.1 Preparer Qualifications: Firm experienced in the analysis, evaluation, and coordination of electrical distribution systems and similar to the system for this project.
- 1.6.2 The study shall be prepared in accordance with the latest edition of NETA ATS, the Canadian Electrical Code, as well as manufacturer's recommendations.
- 1.6.3 Short-Circuit Analysis and Coordination Study shall be performed by a registered Professional Engineer. Study shall be signed and sealed by the Engineer. The Engineer shall have a minimum of eight years experience in the analysis, evaluation, and coordination of electrical distribution systems.
- 1.6.4 The firm conducting the study shall have one million worth of Professional Liability Insurance in addition to standard general insurance.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Independent Testing Organizations
 - 2.1.1.1 AC Tesla.
 - 2.1.1.2 Brosz and Associates.
 - 2.1.1.3 C-INTECH.
 - 2.1.1.4 Eastenghouse.

- 2.1.1.5 Enkompass.
- 2.1.1.6 G.T. Wood.

2.2 PROTECTIVE DEVICE COORDINATION STUDY

- 2.2.1 Prepare coordination time-current characteristic curves to determine the required settings/sizes of the protective devices to maximize selectivity. The utility upstream protective device feeding the facility shall be maintained as the upper limit for coordination. These settings shall be obtained by the preparer, along with any other protective device setting requirements. The coordination curves shall be prepared on log-log paper and illustrate adequate clearing times between series devices. The curves shall be created through the use of the study software package, but must reflect actual protective devices to be installed. Adequate time-current curves shall be generated to depict coordination. In addition, protective device characteristics shall be suitably determined to reflect calculated short-circuit levels at the location.
- 2.2.2 A narrative analysis shall accompany each coordination curve sheet and describe the coordination and protection in explicit detail. All curve sheets shall be multi-colour for improved clarity. Areas lacking complete coordination shall be highlighted and reasons provided for allowing condition to remain or provide solution to resolve situation. System coordination, recommended ratings, and setting of protective devices shall be accomplished by a registered professional electrical engineer with a minimum of eight years of current experience in the coordination of electrical power systems.
- 2.2.3 The following information shall be provided on all curve sheets:
 - 2.2.3.1 Device identification and associated settings/size.
 - 2.2.3.2 Voltage at which curves are plotted.
 - 2.2.3.3 Current multiplier.
 - 2.2.3.4 ANSI frequent fault damage curve.
 - 2.2.3.5 Cable insulation damage curves.
 - 2.2.3.6 Transformer inrush point.
 - 2.2.3.7 Single-line for the portion of the system.
 - 2.2.3.8 Motor starting profiles (where applicable).

2.3 SINGLE LINE DIAGRAM

- 2.3.1 The final report shall include a multi-colour single line diagram of the electrical distribution system within the scope of the project. The single line diagram shall include:
 - 2.3.1.1 Transformer rating, voltage ratio, impedance, and winding connection.
 - 2.3.1.2 Feeder cable phase, neutral and ground sizes, length of cable, conductor material, and conduit size and type.
 - 2.3.1.3 Switchgear, switchboards, panelboards, MCC's, fuses, circuit breakers, ATS's and switches continuous current ratings.
 - 2.3.1.4 Protective relays with appropriate device numbers and CT's and PT's with associated ratios.
 - 2.3.1.5 Detailed legend indicating device type identification and other significant details.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Obtain fault level and X/R ratio information from the utility.

3.2 SUMMARY

- 3.2.1 The results of the system studies shall be summarized in a final report.
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- 3.2.2 Where required, copies of the final report shall be submitted to the Supply Authority for their review and approval. Submit approved copies of the report to the Consultant.

3.3 ADJUSTING

- 3.3.1 The contractor shall engage the manufacturer's service group or alternately a qualified independent testing firm to perform field adjustments of the protective devices as required for placing the equipment in final operating condition. The settings shall be in accordance with the approved short circuit study and protective device evaluation / coordination study.
- 3.3.2 Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with the approved protective device coordination study, shall be carried out by manufacturer's service group.
- 3.3.3 Submit a final service report confirming that settings have been completed.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Provide an Arc Flash Hazard Analysis Study per the requirements described in CSA Z462 Standard for Electrical Safety in the Workplace.
- 1.1.2 The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are obtained in CSA Z462-08, Annex D, or more recent version of the standard as cited by this Section.
- 1.1.3 The scope of the studies shall include all existing distribution equipment and all new distribution equipment supplied by the equipment manufacturer under this contract.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 73.16 – Coordination Studies.
- 1.2.2 Single Line Diagram.

1.3 REFERENCES

- 1.3.1 Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1.3.1.1 IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems.
 - 1.3.1.2 IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
 - 1.3.1.3 IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis.
 - 1.3.1.4 IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings.
 - 1.3.1.5 IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
 - 1.3.1.6 IEEE 1584-2018 - Guide for Performing Arc-Flash Hazard Calculations.
- 1.3.2 American National Standards Institute (ANSI):
 - 1.3.2.1 ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
 - 1.3.2.2 ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures.
 - 1.3.2.3 ANSI C37.010-2016 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
 - 1.3.2.4 ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.
- 1.3.3 CSA Group:
 - 1.3.3.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.3.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.3.3 CSA Z462:21, Workplace electrical safety.

1.4 SUBMITTALS

- 1.4.1 Submit the protective device coordination study to the Consultant prior to receiving final review of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.
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1.5 CLOSEOUT SUBMITTALS

- 1.5.1 The results of the protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. Three (3) bound copies of the complete final report shall be submitted. Additional copies of the complete report with input and output data shall be provided on CD in PDF format.
- 1.5.2 The report shall include the following sections:
 - 1.5.2.1 Executive Summary.
 - 1.5.2.2 Descriptions, purpose, basis, and scope of the study.
 - 1.5.2.3 Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short circuit duties.
 - 1.5.2.4 Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection.
 - 1.5.2.5 Fault current calculations including a definition of terms and guide for interpretation of the computer printout.
 - 1.5.2.6 Details of the incident energy and flash protection boundary calculations.
 - 1.5.2.7 Recommendations for system improvements, where needed.
 - 1.5.2.8 Single Line Diagram.
- 1.5.3 Arc flash labels (refer to CSA Z462 Annex Q) shall be provided in hard copy only.

1.6 QUALIFICATIONS

- 1.6.1 Arc flash hazard analysis studies shall be conducted under the supervision and approval of a licensed Professional Electrical Engineer skilled in performing and interpreting the power system studies.
- 1.6.2 The licensed Professional Electrical Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm.
- 1.6.3 The licensed Professional Electrical Engineer shall have a minimum of eight (8) years of experience in performing power system studies.
- 1.6.4 The equipment manufacturer or approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analysis it has performed in the past year.

1.7 COMPUTER ANALYSIS SOFTWARE

- 1.7.1 The studies shall be performed using the latest revision of the SKM or equivalent.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Independent Testing Organizations:
 - 2.1.1.1 AC Tesla.
 - 2.1.1.2 Brosz and Associates.
 - 2.1.1.3 C-INTECH.
 - 2.1.1.4 Eastenghouse.
 - 2.1.1.5 Enkompass.
 - 2.1.1.6 G.T. Wood.

2.2 STUDIES

- 2.2.1 The contractor shall furnish an Arc Flash Hazard Analysis Study per CSA Z462, reference Section 4.1.8.2.2, 4.3.3.
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2.3 DATA COLLECTION

- 2.3.1 Contractor shall furnish all data as required by the power system studies. The Engineer performing arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
- 2.3.2 Source combination may include present and future motors and generators.
- 2.3.3 If applicable, include fault contribution of existing motors in the study. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.4 ARC FLASH HAZARD ANALYSIS

- 2.4.1 The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in CSA Z462 Annex D.
 - 2.4.2 The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, panelboards, and splitters) where work could be performed on energized parts.
 - 2.4.3 The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 112.5 kVA where work could be performed on energized parts.
 - 2.4.4 Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 calories per square centimetre.
 - 2.4.5 When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.
 - 2.4.6 The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.
 - 2.4.7 The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:
 - 2.4.7.1 Fault contribution from induction motors should not be considered beyond 3-5 cycles.
 - 2.4.8 Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).
 - 2.4.9 For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.
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- 2.4.10 When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
- 2.4.11 Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
- 2.4.12 Arc Flash calculations shall be based on actual overcurrent protective device clearing time.
- 2.4.13 Maximum clearing time will be capped at 2 seconds based on IEEE 1584.
- 2.4.14 Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

2.5 REPORT SECTIONS

- 2.5.1 Incident energy and flash protection boundary calculations:
 - 2.5.1.1 Arcing fault magnitude.
 - 2.5.1.2 Protective device clearing time.
 - 2.5.1.3 Duration of arc.
 - 2.5.1.4 Arc flash boundary.
 - 2.5.1.5 Working distance.
 - 2.5.1.6 Incident energy.
 - 2.5.1.7 Hazard Risk Category.
 - 2.5.1.8 Recommendations for arc flash energy reduction.

3 EXECUTION

3.1 FIELD ADJUSTMENT

- 3.1.1 Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- 3.1.2 Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
- 3.1.3 Notify Owner in writing of any required major equipment modifications.

3.2 ARC FLASH WARNING LABELS

- 3.2.1 The contractor of the Arc Flash Hazard Analysis shall provide a 90 mm (3.5 inch) by 125 mm (5 inch) thermal transfer type label of high adhesion polyester for each work location analyzed.
 - 3.2.2 All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.
 - 3.2.3 The label shall include the following information, at a minimum:
 - 3.2.3.1 Location designation.
 - 3.2.3.2 Nominal voltage.
 - 3.2.3.3 Flash protection boundary.
 - 3.2.3.4 Hazard risk category.
 - 3.2.3.5 Incident energy.
 - 3.2.3.6 Working distance.
 - 3.2.3.7 Engineering firm and issue date.
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- 3.2.3.8 Labels shall be machine printed, with no field markings.
- 3.2.4 Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
 - 3.2.4.1 For each 600 volt, and applicable 208 volt panelboard, one arc flash label shall be provided.
 - 3.2.4.2 For each motor control centre, one arc flash label shall be provided.
 - 3.2.4.3 For each low voltage switchboard, one arc flash label shall be provided.
 - 3.2.4.4 For each switchgear, one flash label shall be provided.
 - 3.2.4.5 For medium voltage switches one arc flash label shall be provided.
- 3.2.5 Arc Flash Warning Label General Instructions:
 - 3.2.5.1 Only qualified electricians who recognize and avoid the electrical and Arc Flash hazards are allowed to place the arc flash warning labels.
 - 3.2.5.2 Electricians should wear suitable PPE, such as electrical safety boots, Safety Glasses, etc. while performing labeling.
 - 3.2.5.3 Generally, arc flash label shall be put on a prominent pre-cleaned place on the front of the electrical equipment (such as switchgear, panel, disconnect switch, generator output breaker). Label should be visible and readable, displayed horizontally, attached flatly and securely, and not allowed to cover other signs or labels on the equipment.
 - 3.2.5.4 Under the special request of the client, labels could be put on the back of the panel door when the panel is located in clean and finished spaces such as an office area.
 - 3.2.5.5 When putting a label on small equipment with no space labeling on the wall just beside the equipment is allowed.
 - 3.2.5.6 Special request may be attached to this General Instruction. For examples, more than one identical label is applied for large equipment; different labels could be applied for different sections of one equipment; for a splitter with several disconnect switches only one label is placed on the splitter for this group.
 - 3.2.5.7 Take the pictures for each label to indicate both names of the label and equipment and labeling area of the equipment. Email these pictures to the Consultant for quality control and record.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Electrical connections to equipment specified in other sections.
- 1.1.2 Conduit rough-ins for future equipment.

1.2 RELATED REQUIREMENTS

- 1.2.1 Division 08 – Openings.
- 1.2.2 Division 11 – Equipment.
- 1.2.3 Division 20 – Common Mechanical Requirements.
- 1.2.4 Division 21 – Fire Suppression.
- 1.2.5 Division 22 – Plumbing.
- 1.2.6 Division 23 – Heating, Ventilating, and Air Conditioning.
- 1.2.7 Division 25 – Integrated Automation.

1.3 REFERENCES

- 1.3.1 NEMA WD 1 - General Colour Requirements for Wiring Devices.
- 1.3.2 NEMA WD 6 - Wiring Devices - Dimensional Requirements.

1.4 COORDINATION

- 1.4.1 Coordinate work to Section 01 31 13.
- 1.4.2 Obtain and review shop drawings, product data, and manufacturer's instructions for equipment provided under other sections.
- 1.4.3 Determine connection locations and requirements.
- 1.4.4 Sequence rough-in of electrical connections to coordinate with installation schedule for equipment.
- 1.4.5 Sequence electrical connections to coordinate with start-up schedule for equipment.

1.5 SUBMITTALS

- 1.5.1 Submit to Section 01 33 00.
- 1.5.2 Product Data: Provide wiring device manufacturer's catalogue information showing dimensions, configurations, and construction.
- 1.5.3 Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.6 REGULATORY REQUIREMENTS

- 1.6.1 Provide products listed and classified by testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

2 PRODUCTS

2.1 COMMON MOTOR REQUIREMENTS

- 2.1.1 Motors up to and including 1/3 hp, shall be 1 phase, 60 Hz, 120 V.
 - 2.1.2 Motors 1/2 hp and above shall be 3 phase, 60 Hz, 575 volts or 208 V.
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2.2 CORDS AND CAPS

- 2.2.1 Attachment Plug Construction: Conform to NEMA WD 1.
- 2.2.2 Configuration: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
- 2.2.3 Cord Construction: NFPA 70, Type SJO multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
- 2.2.4 Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

3 EXECUTION

3.1 CONDUIT PATHWAYS AND ROUGH-INS

- 3.1.1 Where drawings indicate to rough-in conduits for future equipment, or equipment to be provided by the Owner, provide pull string in the conduit, and tag the conduit for the reserved future use/purpose.
- 3.1.2 Where circuits breakers, disconnect switches, or other electrical distribution is provided for future equipment, tag the devices with the reserved future use/purpose.

3.2 WIRING OF EQUIPMENT PROVIDED UNDER OTHER DIVISIONS

- 3.2.1 Use the following procedure with regards to wiring of motors and equipment provided under other Divisions.
 - 3.2.2 The following equipment shall be responsibility of the trade supplying the equipment unless otherwise noted, in accordance with the requirements laid out in the individual section, or this division:
 - 3.2.2.1 Motors.
 - 3.2.2.2 Starters.
 - 3.2.2.3 Variable Frequency Drives.
 - 3.2.2.4 Motor Control Centres.
 - 3.2.2.5 Control wiring.
 - 3.2.3 In every instance, install starter, motor control centre, variable frequency drivers (VFD), etc. and wire to line side of the starter, the Motor Control Centre (MCC), or VFD. Extend wiring from starter, MCC, or VFD to motor as indicated.
 - 3.2.4 Provide all wiring for starters and VFD's from supply to starter to VFD and to motor. Coordinate requirements with the appropriate trade.
 - 3.2.5 Provide 500 mm of liquid tight flexible metal conduit for final connection to motor. Provide disconnect switches where required by code, and as indicated on the drawings.
 - 3.2.6 Where individual starters and controls are grouped together provide a panel for mounting this equipment. Provide a feeder, main fused disconnect and a splitter of adequate size and capacity and wire to line side of the starters on this panel and from starters to motors.
 - 3.2.7 Equipment, General
 - 3.2.7.1 Ascertain exact locations of starters, motor control centres, motors, etc. from drawings and coordinate exact locations with the supplying trade.
 - 3.2.7.2 Control wiring shall be the responsibility of the supplying trade.
 - (1) Control wiring shall be in accordance with Section 26 05 19, and Section 26 05 23.
 - (2) Control wiring shall be installed in conduit in accordance with Section 26 05 33.13.
 - 3.2.8 Doors
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- 3.2.8.1 Ascertain exact locations of door operators, push buttons, automatic sensors, and other door hardware.
 - 3.2.8.2 Provide branch circuit wiring for door operators.
 - 3.2.8.3 Provide control and control wiring for all low voltage door interconnections.
- 3.2.9 Overhead Doors and Folding Vehicle Doors
 - 3.2.9.1 Ascertain exact locations of control panels, remote controls, safety equipment such as safety eyes, overhead door contacts, etc. from shop drawings and architectural drawings, and coordinate exact locations with overhead door trade.
 - 3.2.9.2 Provide branch circuit wiring for door controls.
 - 3.2.9.3 Provide control and control wiring for all low voltage door interconnections.
- 3.2.10 Plumbing Equipment
 - 3.2.10.1 Ascertain exact locations of starters, motor control centres, motors, infra-red plumbing fixture controls from Mechanical Drawings and coordinate exact locations with plumbing trade.
 - 3.2.10.2 Provide branch circuit wiring and an outlet for each infra-red plumbing fixture control.
 - 3.2.10.3 Control wiring shall be the responsibility of the plumbing trade, as described above.
- 3.2.11 HVAC Equipment
 - 3.2.11.1 Ascertain exact locations of starters, motor control centres, motors, motorized dampers, VAV boxes, and heating control valves from HVAC drawings and coordinate exact locations with HVAC Division.
 - 3.2.11.2 In the case of unit heaters, reheat coils and cabinet unit heaters, terminate wiring on terminals provided. Control wiring, thermostats, or other control devices shall be the responsibility of the HVAC trade, as described above.
 - 3.2.11.3 Provide branch circuit wiring and an outlet for each motorized damper, variable air volume (VAV) box, or heating control valve. Control wiring shall be the responsibility of the HVAC trade, as described above.
 - 3.2.11.4 Provide 120 V power connections to small exhaust fans, and ceiling fans for all line voltage control devices, including but not limited to wiring through toggle switches, line voltage thermostats, countdown timer switches, or line voltage speed controllers. Refer to mechanical drawings and schedules for control devices and coordinate requirements with HVAC Division.
 - 3.2.11.5 Provide 120 V wiring connections to duplex receptacles integral with air handling unit control panels.
 - 3.2.11.6 Provide 120 V wiring connections to HVAC maintenance receptacles integral with roof mounted HVAC equipment.
 - 3.2.11.7 Provide 120 V wiring connections to lighting fixture/switch combinations integral with air handling units.
- 3.2.12 Integrated Automation (Building Automation System)
 - 3.2.12.1 Refer to drawing notes for requirements.
 - 3.2.12.2 Provide 120 V wiring connections to BAS system controllers/panels and other control system or component requiring 120 V power including, but not limited to, VAV boxes, dampers, low voltage transformers, etc.
 - 3.2.12.3 From equipment as noted on drawings, extend suitable wiring in conduit from equipment contacts to designated BMS panel serving area, terminating wiring and conduit in a junction box. Leave wiring un-terminated with slack coiled length of minimum 2 m (6 ft) long. Clearly label junction box and wiring end for termination onto BMS panel by respective Mechanical Trade.

3.3 EXAMINATION

- 3.3.1 Verify that equipment is ready for electrical connection, wiring, and energization.

3.4 ELECTRICAL CONNECTIONS

- 3.4.1 Provide a local disconnect switch for all equipment, regardless of if a disconnect switch is shown or not shown on the plans.
- 3.4.2 Make electrical connections to equipment manufacturer's instructions.
- 3.4.3 Make conduit connections to equipment using flexible conduit. Use liquid-tight flexible conduit with watertight connectors in damp or wet locations.
- 3.4.4 Make wiring connections using wire and cable with insulation suitable for temperatures encountered in heat producing equipment.
- 3.4.5 Provide receptacle outlet where connection with attachment plug is indicated. Provide cord and cap where field-supplied attachment plug is indicated.
- 3.4.6 Provide suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- 3.4.7 Install disconnect switches, controllers, control stations, and control devices as indicated.
- 3.4.8 Modify equipment control wiring with terminal block jumpers as indicated.
- 3.4.9 Provide interconnecting conduit and wiring between devices and equipment where indicated.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 The purpose of this section is to specify Division 26 responsibilities in the commissioning process.
- 1.1.2 Commissioning requires the participation of Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 13. Division 26 shall be familiar with all parts of Section 01 91 13 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 REFERENCES

- 1.2.1 2023 ASHRAE Handbook – HVAC Applications, Chapter 43 HVAC Commissioning.
- 1.2.2 ASHRAE Guideline 1.1–2007, HVAC&R Technical Requirements for the Commissioning Process.
- 1.2.3 ASHRAE Guideline 0–2019, The Commissioning Process.
- 1.2.4 ASHRAE Guideline 4–2008 – Preparation of O&M Documentation.
- 1.2.5 ASHRAE/IES Standard 202–2018 – Commissioning Process for Buildings and Systems.
- 1.2.6 CSA Z320-11 (R2021), Building Commissioning Standard & Check Sheets.
- 1.2.7 CSA C282:19, Emergency power supply for buildings.
- 1.2.8 CAN/ULC-S1001-11, Integrated Systems Testing of Fire Protection and Life Safety Systems and Fire Protection Commissioning.

1.3 SUBMITTALS

- 1.3.1 Division 26 Contractors shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 01 91 13, Article “Submittals” for additional Division 26 requirements.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Written work products of Division 26 contractors will consist of the startup and initial checkout plan as described in Section 01 91 13, as well as completed startup, initial checkout, and pre-functional test sheets.

1.5 OPERATIONS AND MAINTENANCE DATA

- 1.5.1 Division 26 contractors shall compile and prepare documentation for all equipment and systems covered in Division 26 and deliver to the GC for inclusion in the O&M manuals.
- 1.5.2 The CxA shall receive a copy of the O&M manuals for review.

1.6 SYSTEMS TO BE COMMISSIONED

- 1.6.1 The following systems shall be commissioned as part of this contract:
 - 1.6.1.1 Interior /Exterior (Site) Lighting Control Systems.
 - 1.6.1.2 All sequences of operation for normal operation.
 - 1.6.1.3 All sequences of operation for failure modes.

1.7 COMMISSIONING TEAM

- 1.7.1 The Commissioning Team shall consist of representatives of the following:
 - 1.7.1.1 Owner and the Owner’s Operating and Maintenance Staff.
 - 1.7.1.2 Architect.
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- 1.7.1.3 Mechanical Design Engineer.
- 1.7.1.4 Commissioning Agent (CxA).
- 1.7.1.5 General Contractor.
- 1.7.1.6 Mechanical Contractor.
- 1.7.1.7 Controls Sub-Contractor.
- 1.7.1.8 Electrical Sub-Contractor.
- 1.7.1.9 Specialized third-party for verification.

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 COMMISSIONING AGENT RESPONSIBILITIES

- 3.1.1 The Commissioning Agent shall:
 - 3.1.1.1 Plan, organize and implement the commissioning process as specified herein.
 - 3.1.1.2 Prepare the commissioning plan, ensure its distribution for review and comment.
 - 3.1.1.3 Revise the commissioning plan as required during construction.
 - 3.1.1.4 Chair commissioning meetings. Prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting.
 - 3.1.1.5 In conjunction with the GC and trades, coordinate commissioning activities.
 - 3.1.1.6 Monitor system verification checks, and ensure the results are documented as the checks are done,
 - 3.1.1.7 Observe select start-ups and initial system operations tests and checks.
 - 3.1.1.8 Direct GC and trades to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes.
 - 3.1.1.9 Witness functional performance tests and document the results.
 - 3.1.1.10 Prepare and submit a commissioning report which documents all checks and tests done throughout the commissioning process, and the results obtained from each.
 - 3.1.1.11 Ensure all required O&M manuals, instructions and demonstrations are provided to the Owner's designated operating staff.

3.2 ENGINEER OF RECORD RESPONSIBILITIES

- 3.2.1 Engineer of Record commissioning responsibilities are outlined below:
 - 3.2.1.1 Review the commissioning plan, and participate, as appropriate, in on-site commissioning meetings.
 - 3.2.1.2 At their discretion during the acceptance phase of the commissioning process, be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

3.3 OWNER'S RESPONSIBILITIES

- 3.3.1 The Owner shall have the following commissioning responsibilities.
 - 3.3.1.1 Ensure the availability of operating staff for all scheduled instruction and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.

3.4 ELECTRICAL CONTRACTOR RESPONSIBILITIES

- 3.4.1 The commissioning responsibilities applicable to the Electrical Contractor are as follows (all references apply to commissioned equipment only):
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- 3.4.1.1 Documentation of all procedures performed shall be provided and forwarded to the engineer. Written documentation must contain recorded test values of all electrical tests performed per the individual product specification.
 - 3.4.1.2 The start-up service company shall be present during energization of the electrical equipment. Jobsite and equipment access must be provided by the Electrical Contractor.
 - 3.4.1.3 The contractor shall supply a power source, specified by the start-up service company, for on-site test equipment.
 - 3.4.1.4 The contractor is to attend all factory witness testing required within the respective specification sections. The contractor is responsible to cover all their costs and include them in their bid.
 - 3.4.1.5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
 - 3.4.1.6 Include the cost of commissioning in the contract price, if not yet let.
 - 3.4.1.7 In each purchase order or subcontract written, include requirements for submittal data, O&M data, and training.
 - 3.4.1.8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process.
 - 3.4.1.9 Contractors shall provide normal cut sheets and shop drawing submittals to the CxA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of pre-functional and functional testing procedures.
 - (1) Typically, this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, full factory testing reports (if any), and full warranty information including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority.
 - (2) The Commissioning Authority may request further documentation necessary for the commissioning process. This data request may be made prior to normal submittals.
 - 3.4.1.10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CxA for review.
 - 3.4.1.11 Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 - 3.4.1.12 Provide assistance to the CxA in preparation of the specific functional performance test procedures specified in Division 26. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
 - 3.4.1.13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CxA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CxA for review.
 - 3.4.1.14 During the startup and checkout process, execute and document the electrical-related portions of the pre-functional test sheets provided by the CxA for all commissioned equipment.
 - 3.4.1.15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.
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- 3.4.1.16 Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
- 3.4.1.17 Perform functional performance testing under the direction of the CxA for specified equipment. Assist the CxA in interpreting the monitoring data, as necessary.
- 3.4.1.18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, PM/GC and A/E and retest the equipment.
- 3.4.1.19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- 3.4.1.20 During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings.
- 3.4.1.21 Provide training of the Owner's operating personnel as specified.
- 3.4.1.22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- 3.4.1.23 Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.
- 3.4.1.24 Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

3.5 SYSTEM STARTUP

- 3.5.1 The Electrical Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 13, Article "Start-up, Pre-Functional Test Sheets, and Initial Checkout." Division 26 has start-up responsibility and is required to complete systems and sub-systems, so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning authority or Owner.
- 3.5.2 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CxA and PM. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all pre-functional test sheets as soon as possible.
- 3.5.3 All equipment shall be started by the Manufacturer's representative.

3.6 PRE-FUNCTIONAL TEST SHEETS

- 3.6.1 Pre-functional test sheets contain items for Division 26 contractors to perform. On each checklist, a column is provided that is to be completed by the contractor assigning responsibility for that line item to a trade. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
 - 3.6.2 Refer to Section 01 91 13 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CxA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off. "Contr." column or abbreviations in
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brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = all Contractors, CxA = Commissioning Agent, CC = Controls Contractor, EC = Electrical Contractor, PM/GC = General Contractor, MC = Mechanical Contractor, SC = Sheet Metal Contractor, TAB = Test and Balance Contractor.

3.7 TRAINING

- 3.7.1 The GC shall be responsible for training coordination and scheduling and ultimately to ensure the training is completed. Refer to Section 01 91 13 for additional details.
- 3.7.2 The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment Refer to Section 01 91 13 for additional details.
- 3.7.3 Electrical Contractor: The Electrical Contractor shall have the following training responsibilities:
 - 3.7.3.1 Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 13, Article "Training".
 - 3.7.3.2 Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.
 - 3.7.3.3 Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
 - 3.7.3.4 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary, and the demonstration repeated.
 - 3.7.3.5 The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
 - 3.7.3.6 The training sessions shall follow the outline in the Table of Contents of the Operation and Maintenance (O&M) manual and illustrate whenever possible the use of the O&M manuals for reference.
 - 3.7.3.7 Training shall include:
 - (1) Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - (2) Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - (3) Discuss relevant health and safety issues and concerns.
 - (4) Discuss warranties and guarantees.
 - (5) Cover common troubleshooting problems and solutions.
 - (6) Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
 - (7) Discuss any peculiarities of equipment installation or operation.
 - 3.7.3.8 Classroom sessions shall include the use of overhead projections, slides, video, and audio taped material as might be appropriate.

- 3.7.3.9 Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and maintenance of all pieces of equipment.
- 3.7.3.10 The Electrical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- 3.7.3.11 Training shall occur after functional testing is complete, unless accepted otherwise by the Project Manager.

3.8 DEFERRED TESTING

- 3.8.1 Refer to Section 01 91 13, Article "Deferred Testing" for requirements of deferred testing.

END OF SECTION

<u>Task</u>	<u>Contractor</u>	<u>Consultant</u>	<u>Commissioning</u>
Manufacturer's Start-Up Checklist Completed			
Cooling System			
Inspect heat exchanger/radiator for leaks, damages and debris			
Check filter cap gasket and sealing surfaces			
Check ventilation louver operation			
Check coolant level, PH level, oil and rust contaminate			
Check hoses and connections for deterioration and tightness			
Check jacket water heater hoses for proper operation			
Check jacket water pump for leaks and unusual noises			
Check coolant conditioner concentration and temperature protection			
Check fan drive pulleys, belts and fan for proper lubrication, tension and wear, and clearance.			
Fuel System			
Verify natural gas isolation valve annunciates at control panel and/or fire alarm annunciator as specified on drawings			
Check fuel lines for leaks and tightness			
Check fuel line brackets for wear points			
Inspect governor oil level			
Check all governor control linkages for free movement			
Inspect primary and secondary fuel filters for leaks			
Air Induction and Exhaust System			
Inspect air filter restriction indicator for reading			
Inspect and clean air filter			
Inspect air filter housing and piping for leaks			
Inspect turbo chargers for oil/exhaust leaks			
Inspect exhaust manifolds for leaks, loose hardware and oil carry over.			
Inspect muffler and piping for leaks, loose hardware, rain cap and supports, drain muffler			
Inspect crankcase vent for restrictions or excessive blow by			
Lubrication System			
Check lube oil level and top up			
Check proper operation of oil pressure gauge			
Check hoses and piping for leaks			
Inspect unit for leaks			
Starting System			
Check starting batteries for electrolyte level and specific gravity.			
Clean and check batteries for loose/corroded connections			
Load test batteries, measure voltage drop			

<u>Task</u>	<u>Contractor</u>	<u>Consultant</u>	<u>Commissioning</u>
Inspect starter for loose connection and unusual noises			
Check battery charger output/float rate and equalize timer			
Inspect battery charger output/float rate and equalize timer			
Inspect charging alternator belts, pulleys and voltage output.			
Engine Monitors and Safety Controls			
Check operation of LOP, HWT and over speed shutdown circuits			
Inspect and test all alarms for proper operation			
Inspect and perform functional test of natural gas valve alarms.			
Inspect wiring harness for weak and loose connections			
Check operation of engine mounted control panel and do an ATS Transfer Test if Allowed.			
Check oil pressure, water temperature, and alternator gauges for readings			
Control Panel			
Check for proper manual operation			
Operational check for correct voltmeter reading (adjust if necessary)			
Operational check for correction ammeter reading			
Operational check for correct frequency reading			
Inspect electrical connections			
Training and Demonstration			
Manufacturer's Performance Verification Checklist submitted to Cx Manager for final PV.			

END OF SECTION

<u>Task</u>	<u>Contractor</u>	<u>Consultant</u>	<u>Commissioning</u>
Manufacturer's Start-Up Checklist Completed			
<u>ATS Visual Inspections</u>			
ATS is correct voltage, ampacity			
Check terminations.			
Check for no voltage on Normal terminals with Normal source locked out and engine start disabled			
Check for no voltage on Emergency terminals with Emergency source locked out and engine start disabled			
Check ATS free from debris			
Check buswork and supporting hardware for carbon tracking, cracks, corrosion, or any other types of deterioration.			
Check stationary and movable contacts.			
Check system hardware for loose connections.			
Check all control wiring and power cables (especially wiring between or near hinged door) for signs of wear or deterioration.			
Check all control wiring and power cables for loose connections.			
Check cabinet interior for loose hardware.			
Check phase rotation.			
Tighten buswork, control wiring, power cables, and system hardware, as necessary.			
<u>ATS Operation</u>			
Connect the set starting batteries. Connect the normal Bypass Operation			
Verify proper operation of the battery charger.			
Test system operation by enabling test function on transfer switch and verify transfer sequence and timers.			
Test system bypass isolation operation.			
Verify Bypass/Isolation interlocks			
Verify Bypass/Isolation indicator lights.			
Close and lock the cabinet door.			
Verify engine startup and transfer to generator on loss of normal source.			
Verify engine cooldown and shutdown after transfer back to normal power.			
Verify alarm contacts.			

<u>Task</u>	<u>Contractor</u>	<u>Consultant</u>	<u>Commissioning</u>
<u>Training and Demonstration</u>			
Manufacturer's Performance Verification Checklist submitted to Cx Manager for final PV.			

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Common requirements for commissioning of all electric lighting, including interior, exterior, and emergency lighting.
- 1.1.2 The party responsible for the functional testing shall not be directly involved in either the design or construction of the project.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 25 56 50 – Integrated Automation Control of Electrical Lighting Systems.
- 1.2.2 Section 26 09 43 – Network Lighting Controls.
- 1.2.3 Section 26 51 19 – LED Interior Lighting.
- 1.2.4 Section 26 52 13.13 – Emergency Lighting.
- 1.2.5 Section 26 56 19 – LED Exterior Lighting.

1.3 REFERENCES

- 1.3.1 ASHRAE
 - 1.3.1.1 ASHRAE Guideline 0-2005 – The Commissioning Process.
 - 1.3.1.2 ANSI/ASHRAE/IES 90.1-2013 – Energy Standard for Building Except Low-Rise Residential Buildings.
- 1.3.2 Illumination Engineering Society (IES)
 - 1.3.2.1 IES DG-29-11 – Design Guide for the Commissioning Process Applied to Lighting and Control Systems.
- 1.3.3 Ontario Building Code
 - 1.3.3.1 Supplementary Standard SB-10: Energy Efficiency Requirements, December 22, 2016 update.

1.4 ACTION SUBMITTALS

- 1.4.1 Refer to Section 01 33 00.
- 1.4.2 Submit sample commissioning forms.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Section 01 77 00: Submittals for project closeout.
 - 1.5.2 Submit commissioning reports.
 - 1.5.2.1 Submit a floor plan or spreadsheet table checklist that indicates each local lighting control device, occupancy sensors, daylighting controls, system component.
 - 1.5.2.2 Submit the system sequence of operation fully describing the equipment components and functionality, including set points and alarm functions.
 - 1.5.2.3 The detailed sequence of operation shall be provided regardless of the completeness and clarity of the sequences in the controls specification and/or drawings.
 - 1.5.3 The functional testing party shall provide documentation certifying that the installed lighting controls meet or exceed all documented performance criteria.
-

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 SITE TESTS AND INSPECTIONS

- 3.1.1 Sensor placement and orientation for all sensor types.
- 3.1.2 Occupancy sensor function, sensitivity, and time delays.
- 3.1.3 Daylight harvesting sensor calibration.
- 3.1.4 Automated shade operation.
- 3.1.5 Manual control placement and operation.
- 3.1.6 Automated control operation, including scheduled on/off functions and dimming trims and presets.
- 3.1.7 Override operation, access, and functionality.
- 3.1.8 Centralized control interfaces and operation.
- 3.1.9 Client education of operations.
- 3.1.10 Documentation archived to client.

3.2 FUNCTIONAL TESTING

- 3.2.1 Lighting control devices and control systems shall be tested to ensure that control hardware and software are calibrated, adjusted, programmed, and in proper working condition in accordance with the construction documents and manufacturer's installation instructions.
- 3.2.2 When occupant sensors, time switches, programmable schedule controls, or photosensors are installed, at a minimum, the following procedures shall be performed:
 - 3.2.2.1 Confirm that the placement, sensitivity, and time-out adjustments for occupant sensors yield acceptable performance, lights turn off only after space is vacated and do not turn on unless space is occupied.
 - 3.2.2.2 Confirm that time switches and programmable schedule controls are programmed to turn the lights off.
 - 3.2.2.3 Confirm that photosensor controls reduce electric lights levels based on the amount of usable daylight in the space as specified.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Materials and installation for contactors for system voltages up to 600 V.

1.2 REFERENCES

- 1.2.1 CSA Group:
 - 1.2.1.1 CSA C22.2 No. 14-18, Industrial Control Equipment.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Allen Bradley "500L" series
- 2.1.2 Eaton.
- 2.1.3 Schneider Electric.
- 2.1.4 Siemens.

2.2 CONTACTORS

- 2.2.1 Contactors: to CSA C22.2 No. 14.
- 2.2.2 Electrically held controlled by pilot devices as indicated and rated for type of load controlled. Half size contactors not accepted.
- 2.2.3 Contactors shall be electrically held 60 Hz, 120 V coil; NEMA Type 1 general purpose enclosure.
- 2.2.4 Fused switch combination contactor as indicated.
- 2.2.5 Complete with 2 normally open and 2 normally closed auxiliary contacts unless indicated otherwise.
- 2.2.6 Mount in CSA Enclosure 1 unless otherwise indicated.
- 2.2.7 Include following options in cover:
 - 2.2.7.1 Red indicating lamp.
 - 2.2.7.2 Hand-Off-Auto selector switch.
- 2.2.8 Provided complete with control transformer, in contactor enclosure.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install contactors and connect auxiliary control devices.

3.2 EQUIPMENT IDENTIFICATION

- 3.2.1 Provide equipment identification in accordance with Section 26 05 53.
- 3.2.2 Size 4 nameplate indicating name of load controlled as indicated.

END OF SECTION

1 GENERAL

1.1 SYSTEM DESCRIPTION

- 1.1.1 Unified Lighting Control System shall consist of BACnet native lighting controllers, Centralized Panels and/or Distributed Controllers, which reside on the BACnet MS/TP network of the Building Automation System (BAS). The Unified Lighting Control System shall be an integral part of the BAS such that the operator experiences one unified system of controlling, monitoring, scheduling, trending, alarming, etc.
 - 1.1.1.1 Systems that require option card, gateway or protocol translator are not acceptable.
 - (1) BACnet MSTP/IP Routers are acceptable when detailed on the drawings.
 - 1.1.1.2 Systems that require separate master controller, server, or front-end computer are not acceptable.
 - 1.1.1.3 Systems that require client or server licensing are not acceptable.
 - 1.1.1.4 Systems that have an actuation time greater than 100 ms are not acceptable. Actuation time is measured from an occupant signal (via low voltage field device; addressable stations, occupancy sensors, wall switches, etc.) to the first relay actuation. Succeeding relays may be delayed to minimize peak demand.
- 1.1.2 Unified Lighting Control System shall also consist of, as detailed on the drawings, satellites, and low voltage field devices such as stations, occupancy sensors, wall switches, and light level sensors.
 - 1.1.2.1 Systems utilizing pre-manufactured cables or proprietary wire to connect low voltage field devices to Centralized Panels, Distributed Controllers, or Satellites are not acceptable.
- 1.1.3 Unified Lighting Control System shall directly control the lighting as specified in this Article 3.6 – Sequence of Operations for Unified Lighting Controls.

1.2 SCOPE OF WORK

- 1.2.1 The BAS Controls Contractor shall furnish all components of the Unified Lighting Control System as detailed on the drawings and specifications. These components shall consist of Centralized Panels, Distributed Controllers, Satellites, and low voltage field devices such as Stations, occupancy sensors, wall switches, and light level sensors. The BAS Controls Contractor shall provide the Electrical Contractor all necessary documents, including approved submittal package, riser diagrams and termination schematics required to provide a complete and correct installation.
- 1.2.2 The Electrical Contractor under Division 26 shall furnish all labor to install the Unified Lighting Control System furnished by the BAS Controls Contractor. The Electrical Contractor shall receive the Unified Lighting Control System components from the BAS Controls Contractor and store them in a secure and dry location. The Electrical Contractor shall provide all of the required materials (conduit, raceways, wire, etc.) and make all of the line and low voltage wiring terminations for the furnished equipment to ensure the Unified Lighting Control System functions properly and in accordance with the specifications and drawings. The Electrical Contractor shall provide installation as-built drawings to the BAS Controls Contractor.

1.3 RELATED REQUIREMENTS

- 1.3.1 The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.
 - 1.3.2 The following sections constitute related work:
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- 1.3.2.1 All sections of Division 25 – Integrated Automation.
- 1.3.2.2 Section 26 05 00 – Common Work Results for Electrical.
- 1.3.2.3 Section 26 27 26 – Wiring Devices.

1.4 CODES AND STANDARDS

- 1.4.1 Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:
 - 1.4.1.1 National Electric Code (NEC)
 - 1.4.1.2 International Building Code (IBC)
 - 1.4.1.3 International Energy Conservation Code (IECC)
 - 1.4.1.4 National Electrical Manufacturer Association (NEMA)
 - 1.4.1.5 ANSI/ASHRAE 135-2010 Rev 12: Data Communication Protocol for Building Automation and Control Systems (BACNET)
 - 1.4.1.6 Underwriters Laboratory (UL) – UL916 Energy Management, UL508 Industrial Control Equipment, and UL924 Emergency Lighting and Power Equipment.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 The Electrical Contractor shall provide complete and accurate as-built drawings to BAS Controls Contractor prior to Unified Lighting Control System Check-out and Testing.
- 1.5.2 The Electrical Contractor shall provide as-built drawings that document all wiring termination information necessary to configure, troubleshoot and complete the Unified Lighting Control System, including but not limited to:
 - 1.5.2.1 Low voltage network wiring information:
 - (1) Type and quantity wires.
 - (2) Distance and route of each wire run.
 - (3) Terminations performed at each device.
 - (4) Junctions performed between devices, if any.
 - 1.5.2.2 Low voltage wiring for low voltage field devices:
 - (1) Type and quantity wires.
 - (2) Distance and route of each wire run.
 - (3) Terminations performed at each device.
 - (4) Junctions performed between devices, if any.
 - 1.5.2.3 Line voltage wiring for Centralized Panels, Distributed Controllers, and Satellites:
 - (1) Circuit identifications and load designation for each relay / line voltage output.
 - (2) Circuit identification for feed to each control power transformer or power source.

1.6 WARRANTY

- 1.6.1 Electrical Contractor shall provide twelve (12) month warranty on the installation of the Unified Lighting Control System. Warranty shall include all labor and materials furnished (including but not limited to; pipe, wire conduit, fasteners, junction boxes, switch boxes, raceways, and face plates) and all line and low voltage wiring terminations. If within twelve (12) months from the date of acceptance of the Unified Lighting Control System, upon written notice from the owner, it is found to be defective in operation, workmanship,

or materials, it shall be replaced, repaired, or adjusted at the option of the Electrical Contractor.

2 PRODUCTS

2.1 MANUFACTURERS

2.1.1 Basis of design is Unified Lighting Control System by Blue Ridge Technologies, Marietta GA (800-241-9173) furnished by the BAS Controls Contractor listed below:

2.1.2 Approved Manufacturer and BAS Controls Contractor:

<u>Manufacturer</u>	<u>BAS Controls Contractor</u>
Blue Ridge Technologies (basis of design).	AccuTemp Systems.
Honeywell Unitary Controller/Kele LDIM2 driver module.	Ace Solutions.
Approved equal.	Other City of Mississauga approved BAS vendors.

2.1.3 All proposed Manufacturer and BAS Controls Contractor substitutions must be submitted in writing for approval by the design professional (electrical or mechanical) a minimum of ten (10) working days prior to the bid date. Proposed substitutions must be accompanied by a review of the specification noting compliance on a line-by-line basis.

2.1.4 BAS Controls Contractors using pre-approved substitutions accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. In addition, the BAS Controls Contractor shall provide complete engineered shop drawings including power and control wiring with deviations from the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.2 CENTRALIZED PANELS

2.2.1 The Electrical Contractor shall install Centralized Panels as detailed on drawings.

2.2.1.1 The BAS Controls Contractor under Division 25 shall furnish Centralized Panels as detailed on drawings.

2.3 DISTRIBUTED CONTROLLERS

2.3.1 The Electrical Contractor shall install Distributed Controllers as detailed on drawings.

2.3.1.1 The BAS Controls Contractor under Division 25 shall furnish Distributed Controllers as detailed on drawings.

2.4 SATELLITES

2.4.1 The Electrical Contractor shall install Satellites as detailed on drawings.

2.4.2 The BAS Controls Contractor under Division 25 shall furnish Satellites as detailed on drawings.

2.5 LOW VOLTAGE WALL SWITCHES

2.5.1 The Electrical Contractor shall install low voltage wall switches as detailed on drawings.

2.5.1.1 The BAS Controls Contractor under Division 25 shall furnish Low Voltage Wall Switches as detailed on drawings.

2.5.1.2 The Electrical Contractor shall furnish and install all face plates with labels or engraving as required. The BAS Controls Contractor under Division 25 shall provide the text for labeling of all faceplates.

- 2.5.1.3 Line voltage wall switches that are not part of the Unified Lighting Control System shall be furnished and installed by the Electrical Contractor, under Division 26.
- 2.5.1.4 Low voltage switches shall be gang-able with other low voltage decorator style devices under a common face plate.

2.6 LOW VOLTAGE STATIONS

- 2.6.1 The Electrical Contractor shall install low voltage stations and shall set the station address as detailed on drawings.
 - 2.6.1.1 The BAS Controls Contractor under Division 25 shall furnish low voltage stations as detailed on drawings.
 - 2.6.1.2 The Electrical Contractor shall furnish and install all face plates with labels or engraving as required. The BAS Controls Contractor under Division 25 shall provide the text for labeling of all faceplates.
 - 2.6.1.3 Low voltage stations shall be gang-able with other low voltage decorator style devices under a common face plate.

2.7 LOW VOLTAGE LIGHT LEVEL SENSORS

- 2.7.1 The Electrical Contractor shall install low voltage light level sensors as detailed on drawings.
 - 2.7.1.1 The BAS Controls Contractor under Division 25 shall furnish low voltage light level sensors as detailed on drawings.
 - 2.7.1.2 Refer to approved BAS Controls Contractor documents for location.

2.8 LOW VOLTAGE OCCUPANCY SENSORS

- 2.8.1 The Electrical Contractor shall install low voltage occupancy sensors and shall set the time-out value as detailed on drawings.
 - 2.8.1.1 The BAS Controls Contractor under Division 25 shall furnish low voltage occupancy sensors as detailed on drawings.
 - 2.8.1.2 Line voltage occupancy sensors that are not part of the Unified Lighting Control System shall be furnished and installed by the Electrical Contractor, under Division 26.
 - 2.8.1.3 All low voltage occupancy sensor timers shall be set to the minimum setting, 1 minute or less, by the installer.
 - 2.8.1.4 All low voltage occupancy sensor adjustments for sensing area / coverage shall be set by the installer. Installer shall be responsible for any fine tuning of settings to provide proper operation.

2.9 LINE VOLTAGE OCCUPANCY

- 2.9.1 BAS Controls Contractor shall provide line voltage occupancy sensors that are directly connected to the Unified Lighting Control System.
 - 2.9.1.1 Electrical Contractor under Division 26 shall install all line voltage occupancy sensors as detailed on the drawings and in accordance with the manufacturer's recommendation.
- 2.9.2 Line voltage occupancy sensors that are not part of the Unified Lighting Control System shall be furnished and installed by the Electrical Contractor, under Division 26.

2.10 LINE VOLTAGE SWITCHES

- 2.10.1 All line voltage switches shall be furnished and installed by the Electrical Contractor, under Division 26.
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3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install and wire all Unified Lighting Control System equipment furnished by the BAS Controls Contractor. All work, materials and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:
 - 3.1.1.1 National Electric Code (NEC).
 - 3.1.1.2 International Building Code (IBC).
 - 3.1.1.3 International Energy Conservation Code (IECC).
 - 3.1.1.4 ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACNET).
 - 3.1.1.5 Underwriters Laboratory (UL) – UL 916 Energy Management, UL 508 Industrial Control Equipment, and UL 924 Emergency Lighting and Power Equipment.
- 3.1.2 Installation shall include all low voltage wiring and terminations in accordance with the drawings and submittals provided by the BAS Controls Contractor, including wiring and terminations:
 - 3.1.2.1 between Centralized Panels Distributed Controllers, and Satellites and low voltage field devices (including but not limited to low voltage switches, low voltage stations, low voltage occupancy sensors, and low voltage light level sensors).
 - 3.1.2.2 between Centralized Panels, Distributed Controllers, and Satellites and the 0-10 Vdc dimming driver(s). Applies to 0-10 Vdc dimming driver control leads (pink and violet) that are wired as CL2.
- 3.1.3 Installation shall include all line voltage wiring and terminations in accordance with the drawings and submittals provided by the BAS Controls Contractor, including wiring and terminations:
 - 3.1.3.1 between Centralized Panels, Distributed Controllers, and Satellites and line voltage loads.
 - 3.1.3.2 between Centralized Panels, Distributed Controllers, and Satellites and the 0-10 Vdc dimming driver(s). Applies to 0-10 Vdc dimming driver control leads (pink and violet) that are wired as CL1.
- 3.1.4 Installation shall include all low voltage network wiring and terminations in accordance with the drawings and submittals provided by the BAS Controls Contractor, including wiring and terminations:
 - 3.1.4.1 The BACnet network.
 - 3.1.4.2 Addressable station and satellite controller network.

3.2 PROGRAMMING

- 3.2.1 All programming of the Unified Lighting Control System as specified shall be furnished by the BAS Controls Contractor under Division 25.
- 3.2.2 The Electrical Contractor shall provide complete and accurate as-built drawings to BAS Controls Contractor upon completion of installation.

3.3 SYSTEM CHECKOUT AND TESTING

- 3.3.1 Prior to system check-out and testing by the BAS Controls Contractor, the Electrical Contractor shall verify that all line and low voltage wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
 - 3.3.2 Prior to system check-out and testing by the BAS Controls Contractor and prior to final termination of control leads at Centralized Panel, Distributed Controllers, and Satellites
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the Electrical Contractor shall demonstrate to BAS Controls Contractor that all 0-10 Vdc dimming drivers operate as follows:

- 3.3.2.1 Open 0-10 Vdc control leads to demonstrate that all 0-10 Vdc dimming drivers connected achieve full (100%) light output.
- 3.3.2.2 Short 0-10 Vdc control leads to each other to demonstrate that all 0-10 Vdc dimming drivers connected achieve minimum (typically 5%) light output.
- 3.3.2.3 Lamp flicker, tiger tails, or irregularities with the 0-10 Vdc dimming drivers are not acceptable. Replace, re-wire, or repair 0-10 Vdc dimming driver as required.
- 3.3.2.4 Lamps shall be operated at full output for 100 continuous hours prior to system check-out and testing.

3.4 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- 3.4.1 After tests described in this specification are performed by the BAS Controls Contractor to the satisfaction of the Engineer, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide written statement of each exempted test.
- 3.4.2 The system shall not be accepted until completed demonstration forms and checklists are submitted and approved.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Metering transformer cabinets.
- 1.1.2 Meter bases.
- 1.1.3 Utility Requirements.
- 1.1.4 A new service will be provided from a padmount transformer, built to the requirements of the Local Hydro Authority as per the utility's standard details.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 24 13 – Switchboards: Metering transformer compartment.
- 1.2.2 Electrical Utility's Offer to connect.

1.3 REFERENCES

- 1.3.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
- 1.3.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.3.3 Ontario Building Code and its referenced standards.
- 1.3.4 CSA C22.2 No. 52-17, Underground Service-Entrance Cables.
- 1.3.5 Alectra Utilities standards.

1.4 PRE-INSTALLATION MEETINGS

- 1.4.1 Convene one week prior to commencing work of this section.
- 1.4.2 Review service entrance requirements and details with utility company's representatives.

1.5 ACTION SUBMITTALS

- 1.5.1 Product Data: Provide ratings and dimensions of transformer cabinets and meter bases.

1.6 INFORMATIONAL SUBMITTALS

- 1.6.1 Submit utility company's prepared drawings.

1.7 QUALITY ASSURANCE

- 1.7.1 Perform Work to utility company's written requirements.
- 1.7.2 Obtain approval from Supply Authority and Inspection Authority on complete service. Coordinate work with Utility.
- 1.7.3 Maintain one copy of each document on site.

1.8 REGULATORY REQUIREMENTS

- 1.8.1 Products: Listed and classified by testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

2 PRODUCTS

2.1 DESCRIPTION

- 2.1.1 Electric Utility Company: Alectra Utilities (formerly Enersource Hydro Mississauga).
 - 2.1.2 System Characteristics: 800 A (100% rated), 600Y/347 V, 3-phase, 4-wire.
 - 2.1.3 Available Fault Current: To be confirmed with utility.
-

2.2 METERING TRANSFORMER CABINET

- 2.2.1 Manufacturers: As per Utility Requirements
- 2.2.2 Description: Sheet metal cabinet with hinged door, conforming to utility company requirements, with provisions for locking and sealing.
- 2.2.3 Dimensions: 1220 mm wide by 1200 mm high by 305 mm deep (48 in by 48 in by 12 in).

2.3 METER BASES

- 2.3.1 Meter Base: Supplied by utility company.

2.4 PT'S AND CT'S

- 2.4.1 Supplied by the utility for inclusion in main switchboard.

2.5 PADMOUNT TRANSFORMER FOUNDATION (SUPPLIED AND INSTALLED BY THIS CONTRACTOR)

- 2.5.1 In accordance with local utility standards.
- 2.5.2 Provide grounding to utility specifications.

3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

- 3.1.1 Verify that field measurements are as indicated on utility company's drawings.

3.2 PREPARATION

- 3.2.1 Arrange with utility company to obtain permanent electric service to the project.

3.3 INSTALLATION

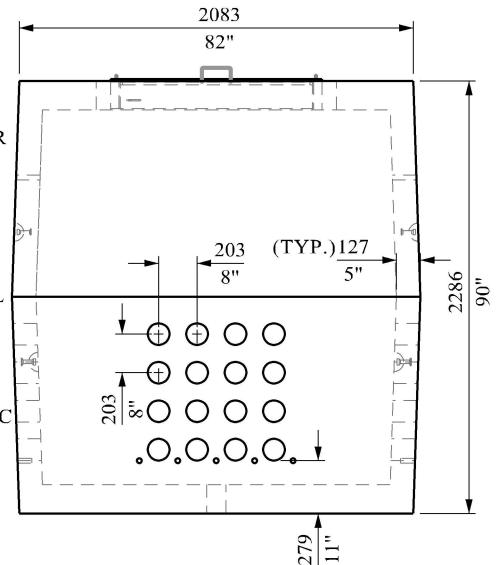
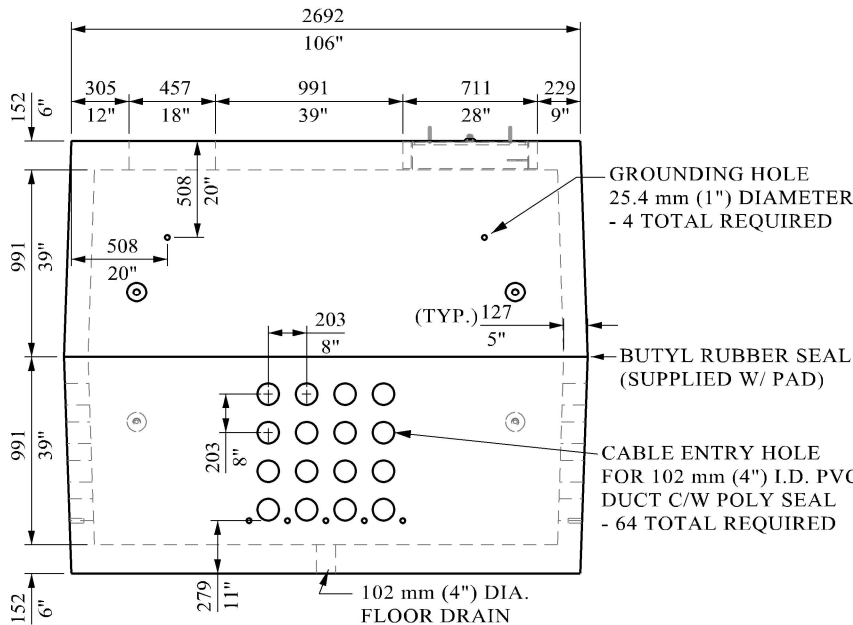
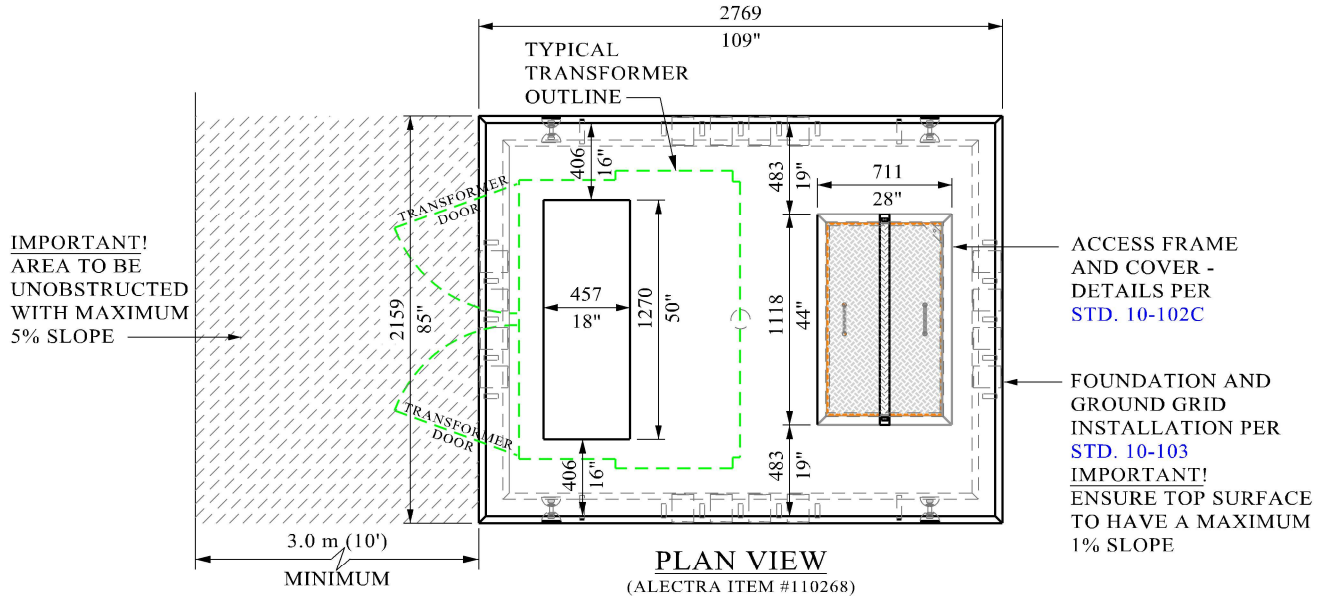
- 3.3.1 Local Hydro Authority will provide high voltage cable and transformer. Primary duct bank, transformer vault and pad, secondary duct, secondary cable, grounding etc., to be provided by this Division.
- 3.3.2 Utility Metering (supplied by Local Hydro Utility)
 - 3.3.2.1 Current and potential transformers for utility metering shall be in accordance with requirements of Supply Authority.
 - 3.3.2.2 Equipment manufacturer shall submit complete metering details for approval to utility and obtain their approval prior to manufacture.
 - 3.3.2.3 Compartment housing utility metering transformers shall be suitable for utility padlocking.
- 3.3.3 Metering Instruments
 - 3.3.3.1 A flush mounted voltmeter and a flush mounted ammeter, along with three phase selector switches and associated metering transformers shall be provided.
- 3.3.4 Work of this and related requirements
 - 3.3.4.1 Provision of concrete encased primary and secondary ducts, transformer vault to Local Hydro Authority requirements. Provision of fish wire in primary ducts.
 - 3.3.4.2 Provision of feeder from transformer to main switch.
 - 3.3.4.3 Grounding installation.
 - 3.3.4.4 Provision of metering cabinets in accordance with utility requirements, and all required conduits.
 - (1) Install metering cabinets such that the top of the cabinet is 1.8 m (6 ft) to the top of the enclosure.

- (2) Provide a 120 V duplex receptacle in the metering cabinet on a dedicated circuit.
 - (3) Provide conduits from switchboard to the metering cabinet.
 - (4) Provide conduit from the metering cabinet to the telephone room or other meter reading point.
- 3.3.5 Work by the Local Hydro Authority
 - 3.3.5.1 Provision of transformer.
 - 3.3.5.2 Provision of all equipment at property line.
 - 3.3.5.3 Termination of medium voltage cables at both ends with stress cones.
 - 3.3.5.4 Termination of secondary cables and ground cable(s) at transformer.
- 3.3.6 Service Entrance
 - 3.3.6.1 Connect to service entrance breaker as shown and as specified.
 - 3.3.6.2 Provide incoming and outgoing cable connections, torque same as required.
 - 3.3.6.3 Ground equipment as required by Code.
- 3.3.7 Provide complete shop drawings for all distribution equipment. Local Hydro Authority will provide high voltage cable and transformer. Primary duct, transformer vault, secondary duct, secondary cable, grounding etc., to be provided by this Contractor.

END OF SECTION

SECTION 26 21 16.01
ALECTRA UTILITIES ELECTRICAL SERVICE DETAILS

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BROOKLIN CONCRETE PRODUCTS
(BCP - 104SM)
NEWMARKET
Tel. No. 1-888-407-6443

UTILICON
(UV85109MM)
BRADFORD
Tel. No. (905) 778-8400

NOTES:

1. CONCRETE SHALL BE MINIMUM 30 MPa, AIR-ENTRAINED AND LOW SLUMP
2. TO BE CONSTRUCTED AS PER CSA A23.1 AND TESTED AS PER CSA A23.2 (LATEST EDITION)
3. CABLE OPENING ON TOP AND SIDE CABLE ENTRY HOLES SHALL HAVE SMOOTH-FINISHED SURFACES AND EDGES
4. HOLES MAY SLIGHTLY VARY FROM ONE MANUFACTURER TO ANOTHER
5. APPROXIMATE WEIGHT (TOTAL) = 9,680 kg / 21,300 lbs

M LINEAR DIMENSIONS SHOWN IN MILLIMETRES

R2 (MAR 2016)

DRAWING AND NOTE 4
UPDATED. ICS REMOVED

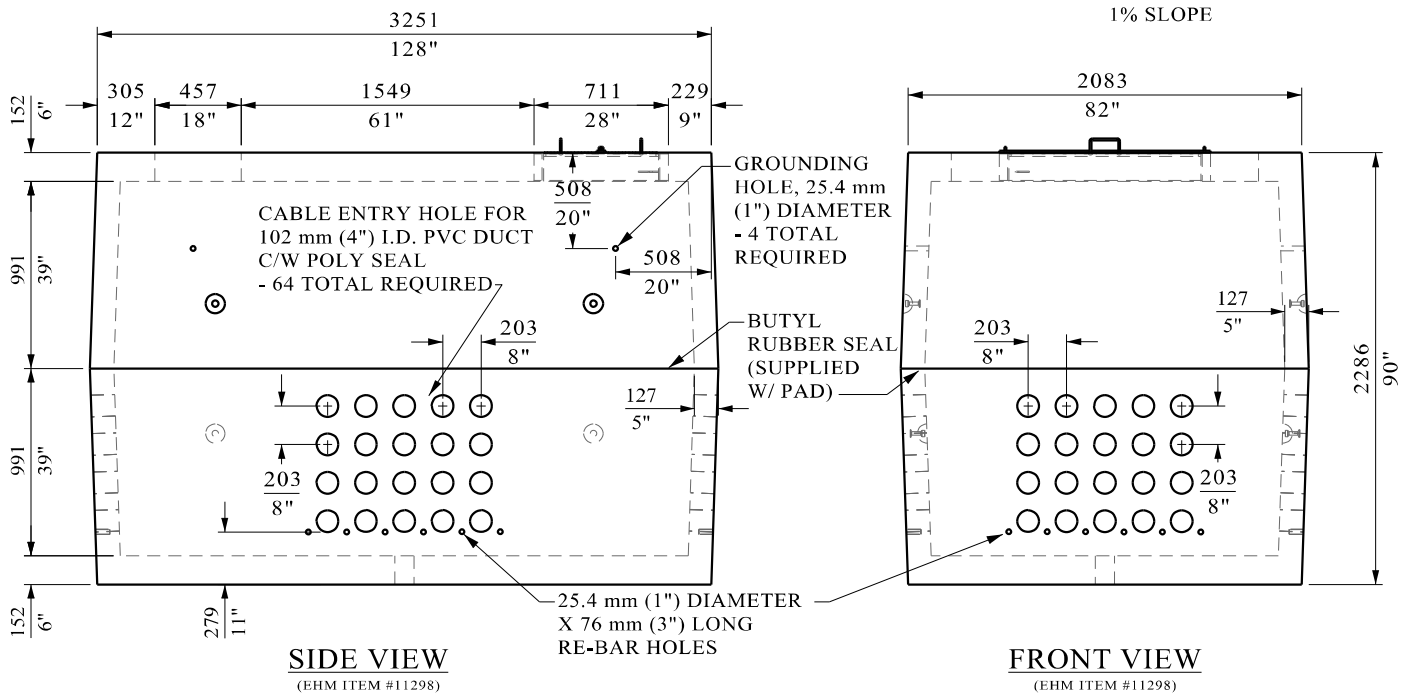
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APPROVED BY: P.K.

[illegible]

– FOUNDATION AND
GROUND GRID
INSTALLATION PER
STD. 10-103

IMPORTANT!
ENSURE TOP SURFACE
TO HAVE A MAXIMUM
1% SLOPE

PLAN VIEW
(EHM ITEM #11298)



BROOKLIN CONCRETE PRODUCTS
(BCP - 115SM)
NEWMARKET
Tel. No. 1-888-407-6443

UTILICON
(UV85132MM)
BRADFORD
Tel. No. (905) 778-8400

1. CONCRETE SHALL BE MINIMUM 30 MPa, AIR-ENTRAINED AND LOW SLUMP
2. TO BE CONSTRUCTED AS PER CSA A23.1 AND TESTED AS PER CSA A23.2 (LATEST EDITION)
3. CABLE OPENING ON TOP AND SIDE CABLE ENTRY HOLES SHALL HAVE SMOOTH-FINISHED SURFACES AND EDGES
4. HOLES MAY SLIGHTLY VARY FROM ONE MANUFACTURER TO ANOTHER
5. APPROXIMATE WEIGHT (TOTAL) = 13,160 kg / 29,000 lbs

DATE : Mar-2004

TWO PIECE PRE-CAST CONCRETE
FOUNDATION FOR 3-PHASE PAD MOUNTED
TRANSFORMER, 750 kVA TO 3000 kVA

13.8 kV AND 27.6 GrdY/16000 kV

JDE KITS:
K10-102A-FDN-3PH-3000
KVA (1681)

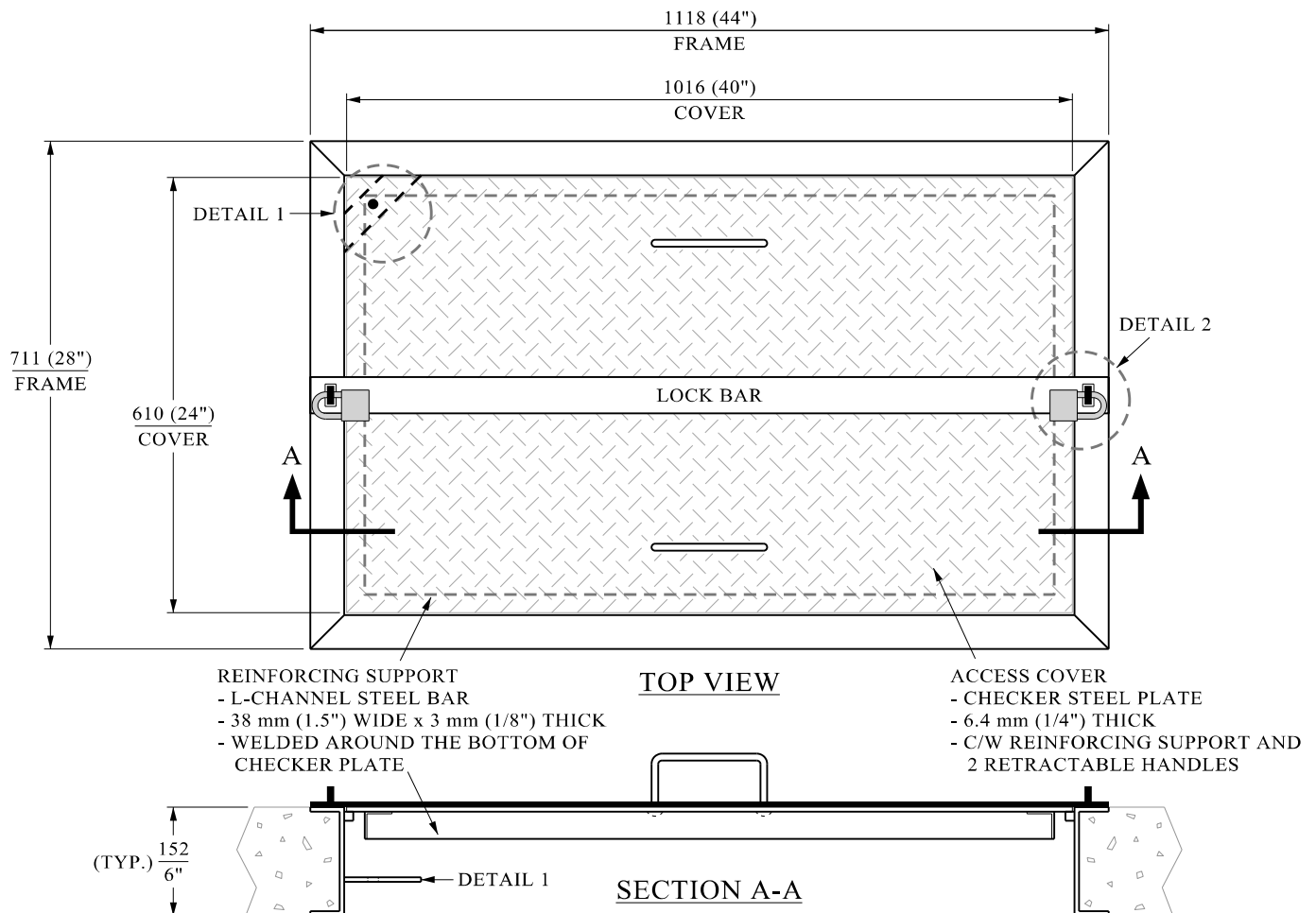
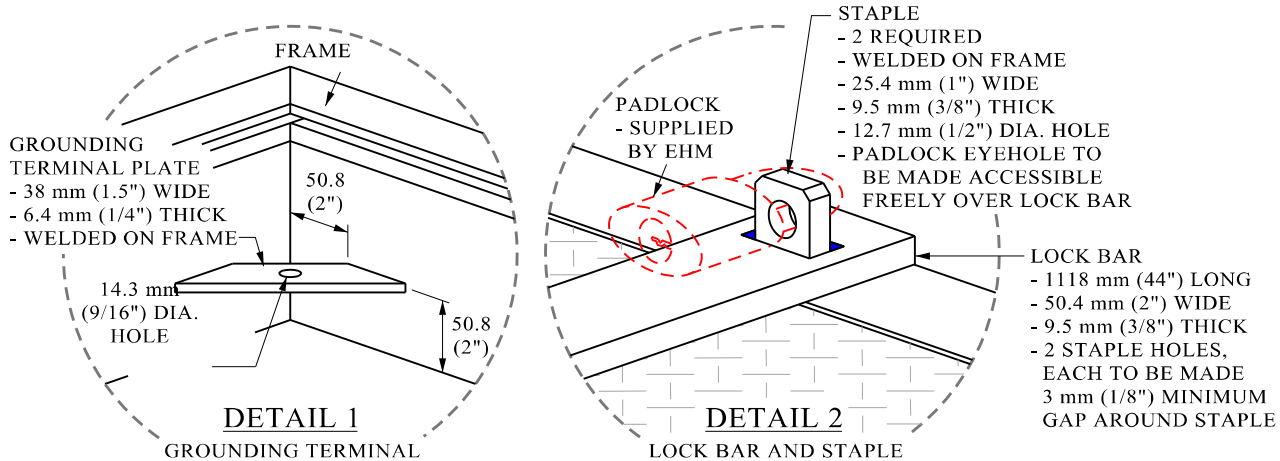
ENERSOURCE

HYDRO MISSISSAUGA

LINEAR DIMENSIONS SHOWN IN MILLIMETRES

10-102C

MAR 2014



NOTES:

- FRAME SHALL BE MADE OF MINIMUM 6.4 mm (1/4") THICK STEEL
- WELDING AS PER CSA W47.1 (LATEST EDITION)
- ALL PARTS SHALL BE MADE SMOOTH AND FREE OF SHARP EDGES
- AFTER FABRICATION, HOT DIP GALVANIZED AS PER CSA G164 (LATEST EDITION)
- PRE-CAST CONCRETE FOUNDATION AS PER [STD. 10-101](#) AND [10-102A](#).
- THIS DRAWING SUPERSEDES STD. 37-324C REVISION 2, ISSUED ON FEB. 2010.

ORIGINAL:

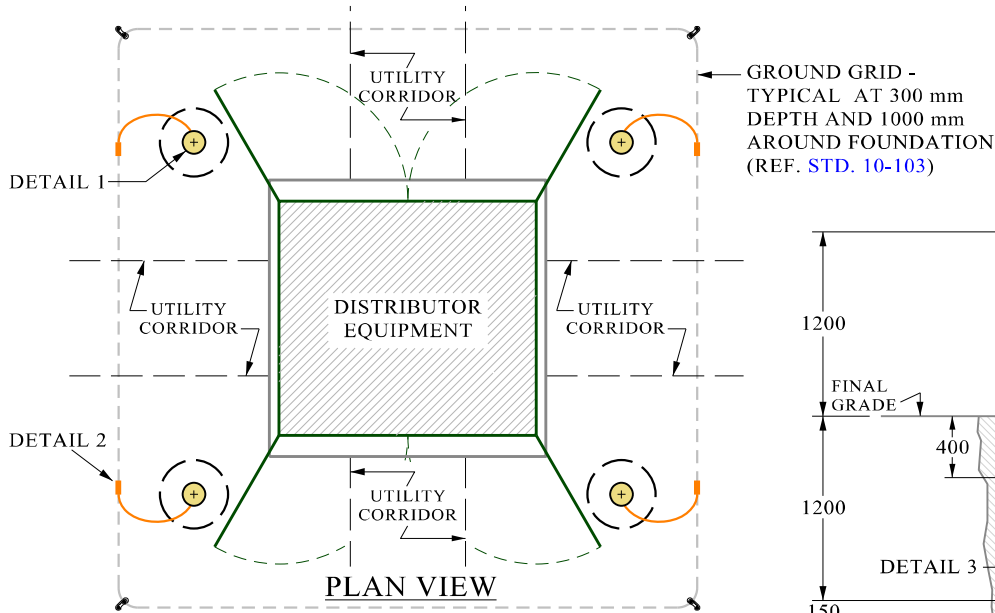
CHECKED BY : A.H.
APPROVED BY : R.B.

DATE : Mar-2014

ACCESS FRAME AND COVER FOR PAD-MOUNTED, 3-PHASE TRANSFORMER FOUNDATION

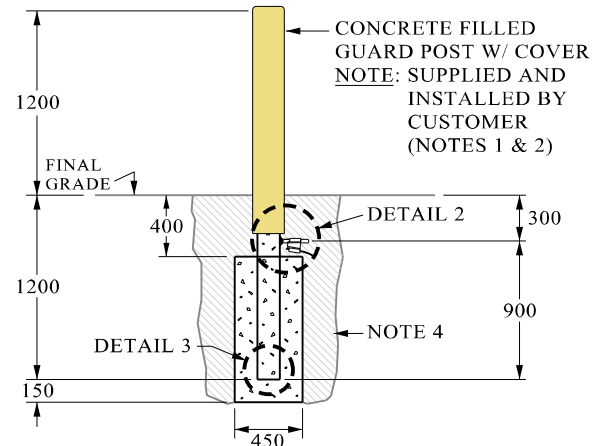
JDE KITS:

N/A

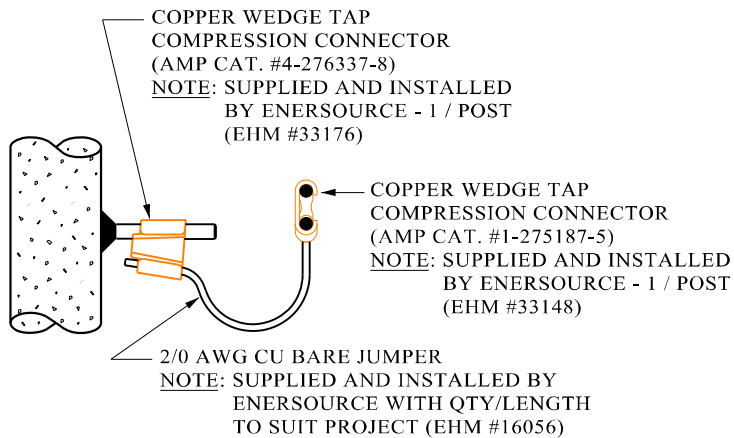


REVISION #2:
NOTE 1 UPDATED AND
NOTE 6 REMOVED

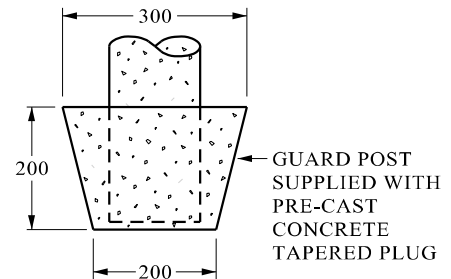
CHECKED BY: A.C.
APPROVED BY: P.K.



DETAIL 1: GUARD POST



DETAIL 2: GROUNDING



DETAIL 3: OPTIONAL BASE

NOTES:

1. THE GUARD POSTS SHALL BE 150 mm DIAMETER X 2.4 m LONG X 6 mm THICK (6" DIA. X 8' LONG, SCHEDULE 40) GALVANIZED STEEL PIPE C/W 3/4" X 8" COPPER CLAD GROUNDING STUD (DETAIL 2), AND A COVER MADE OF HIGH DENSITY POLYETHYLENE (HDPE) WITH BUILT-IN ULTRAVIOLET AND HIGH IMPACT RESISTANCE AND COLOUR IN SAFETY YELLOW.
2. THE LOCATION AND NUMBER OF GUARD POSTS SHALL BE DETERMINED AND CONFIRMED BY ENERSOURCE'S FIELD INSPECTOR AND SHALL MEET THE FOLLOWING CRITERIA:
 - 2.1. ALLOW EQUIPMENT DOORS (INCLUDING SUB-COMPARTMENT'S DOORS) TO BE OPENED THROUGH THEIR FULL RANGE.
 - 2.2. ALLOW ENERSOURCE'S AUTHORIZED PERSONNEL UNIMPEDED ACCESS TO THE EQUIPMENT AND PERMIT SAFE OPERATION OF THE EQUIPMENT.
 - 2.3. ALLOW A 500 mm MINIMUM CLEARANCE BETWEEN THE GUARD POST'S CONCRETE ENCASEMENT AND THE UTILITY CORRIDOR.
 - 2.4. ALLOW A 100 mm MINIMUM CLEARANCE BETWEEN THE GUARD POST'S CONCRETE ENCASEMENT AND THE GROUND GRID.
3. THE GUARD POSTS SHALL BE ENCASED AND FILLED WITH CONCRETE (30 MPa) AS PER DETAIL 1, OR TO BE SUPPLIED WITH PRE-CAST CONCRETE TAPERED PLUG (DETAIL 3).
4. WHERE GUARD POSTS ARE INSTALLED IN BACKFILL OR DISTURBED EARTH, ENSURE BACKFILL MATERIAL IS THOROUGHLY COMPACTED.
5. ALL GUARD POSTS SHALL BE BONDED TO GROUND GRID AS PER DETAIL 2.

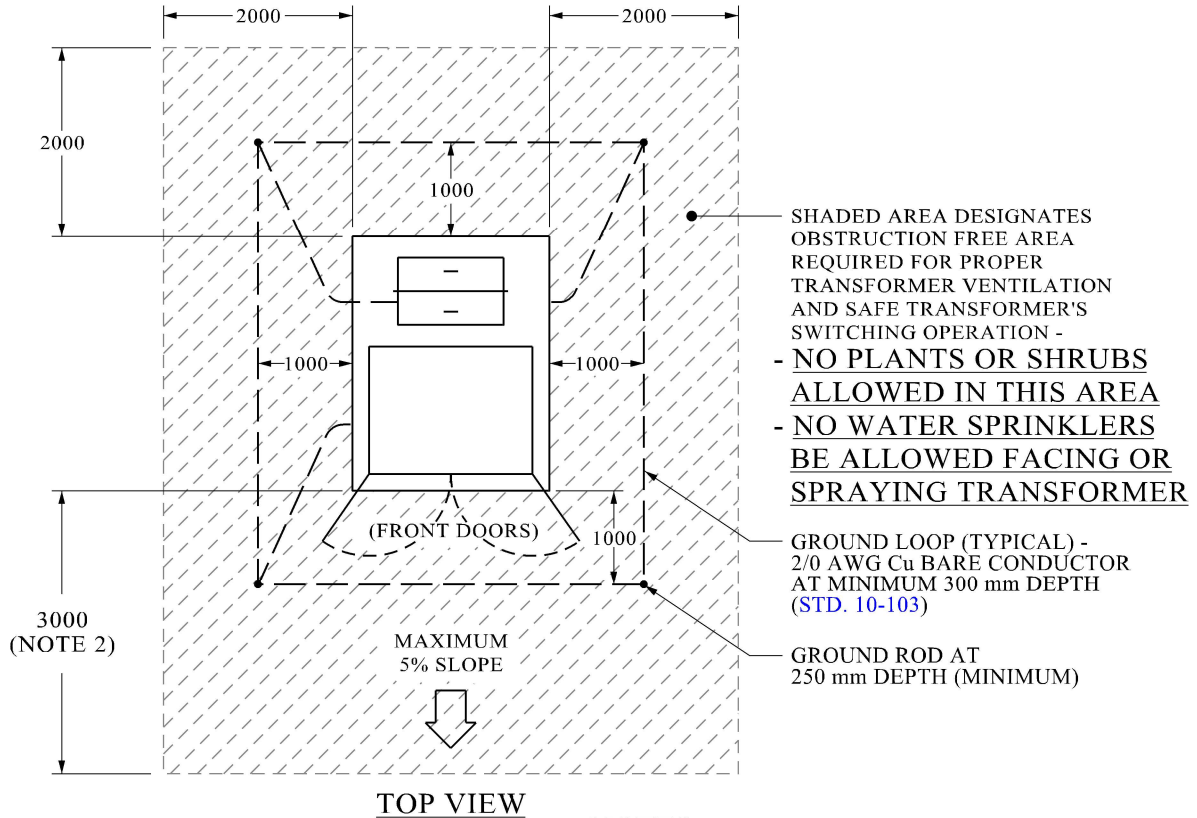
ORIGINAL:
CHECKED BY : G.S.
APPROVED BY : D.C.

DATE : Mar-2004

**TYPICAL GUARD POST
INSTALLATION**

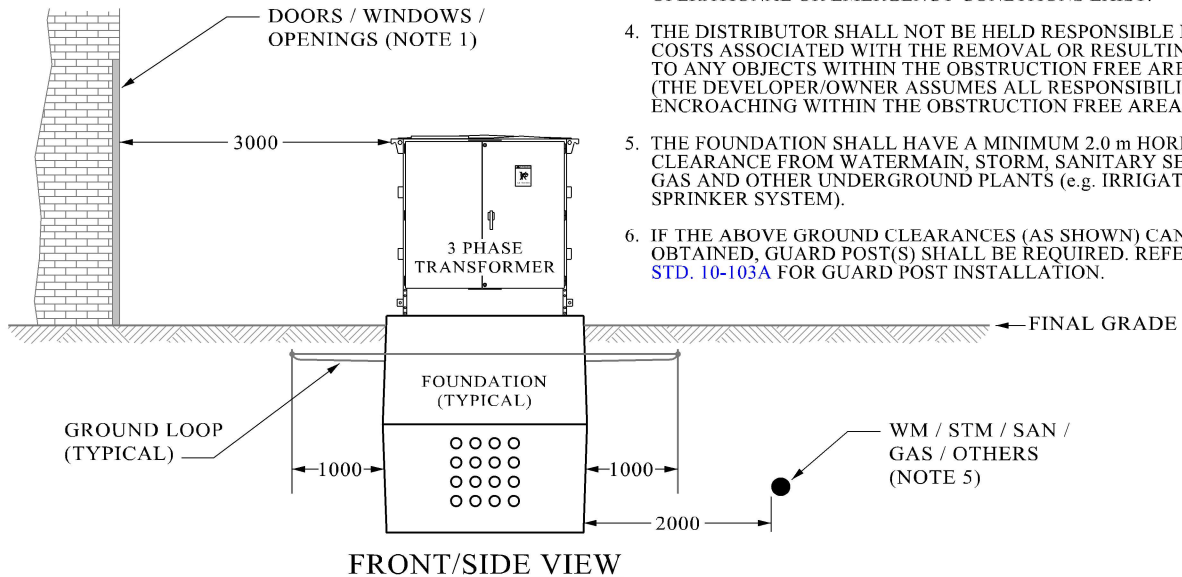
JDE KITS:
K10-103A-AMPACT-1POST
(1677)
K10-103A-CADWELD-1POST
(1678)

Note: 1 Kit / Post



NOTES:

1. A MINIMUM 3.0 m CLEARANCE SHALL BE REQUIRED FROM ALL SIDES OF TRANSFORMER TO ANY DOORS, WINDOWS OR OPENINGS OF A BUILDING. IF CLEARANCE CAN NOT BE ACHIEVED CONTACT THE DISTRIBUTOR PRIOR TO INSTALLATION.
2. A MINIMUM 3.0 m FLAT SURFACE AND OBSTRUCTION FREE CLEARANCE SHALL BE REQUIRED IN FRONT OF TRANSFORMER.
3. ANY AND ALL OBJECTS WITHIN THE OBSTRUCTION FREE AREA, ARE SUBJECT TO REMOVAL WITHOUT ANY PRIOR NOTICE SHOULD OPERATIONAL OR EMERGENCY CONDITIONS EXIST.
4. THE DISTRIBUTOR SHALL NOT BE HELD RESPONSIBLE FOR ANY COSTS ASSOCIATED WITH THE REMOVAL OR RESULTING DAMAGE TO ANY OBJECTS WITHIN THE OBSTRUCTION FREE AREA. (THE DEVELOPER/OWNER ASSUMES ALL RESPONSIBILITY FOR ENCROACHING WITHIN THE OBSTRUCTION FREE AREA.)
5. THE FOUNDATION SHALL HAVE A MINIMUM 2.0 m HORIZONTAL CLEARANCE FROM WATERMAIN, STORM, SANITARY SERVICES, GAS AND OTHER UNDERGROUND PLANTS (e.g. IRRIGATION SPRINKER SYSTEM).
6. IF THE ABOVE GROUND CLEARANCES (AS SHOWN) CAN NOT BE OBTAINED, GUARD POST(S) SHALL BE REQUIRED. REFER TO [STD. 10-103A](#) FOR GUARD POST INSTALLATION.



JDE KITS:
N/A

REVISION 2:
 REDRAWN TO SCALE
 CHECKED BY: G.S.
 APPROVED BY: R.B.

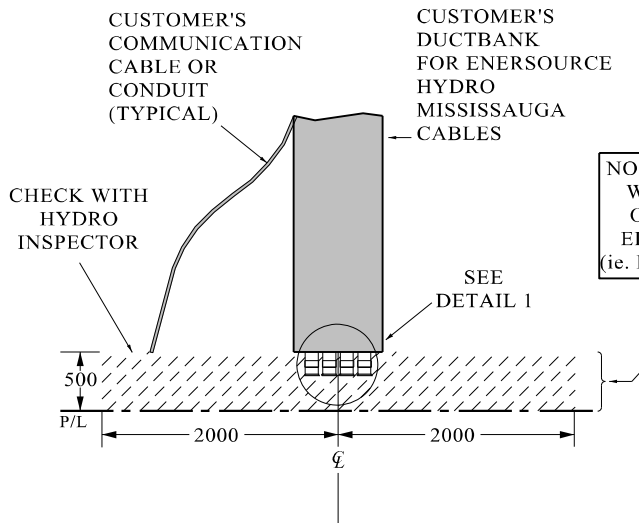


FIGURE 1
PROPERTY LINE (P/L) TERMINATION
(TYPICAL)

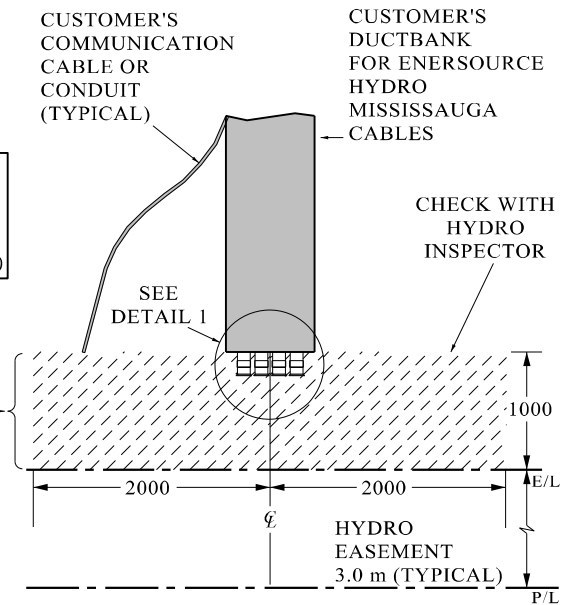
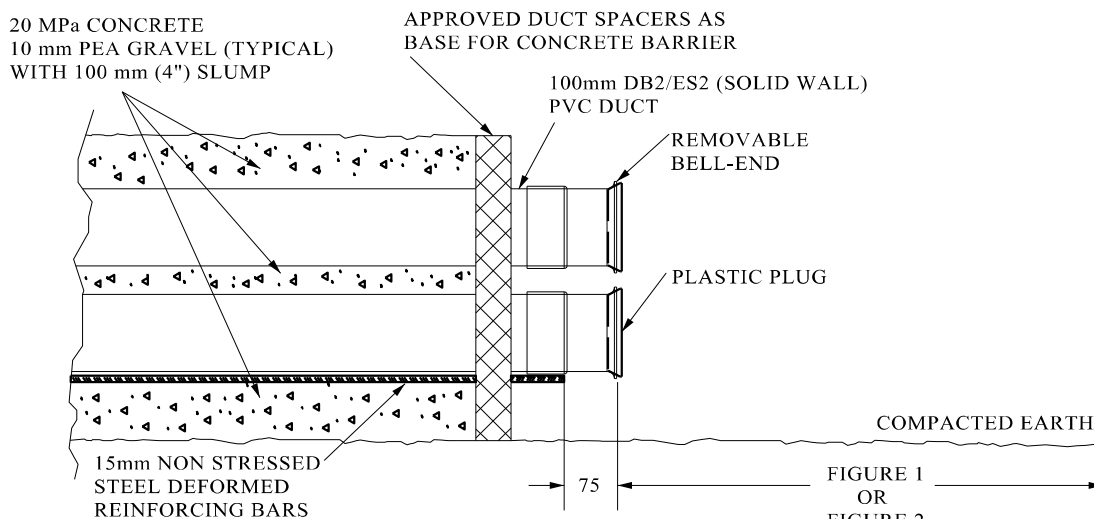


FIGURE 2
EASEMENT LINE (E/L) TERMINATION
(TYPICAL)



DETAIL 1
100 mm (4\") DUCTS EXTENSION

ORIGINAL:
 CHECKED BY : M.H.
 APPROVED BY : D.C.
 DATE : Mar-2004

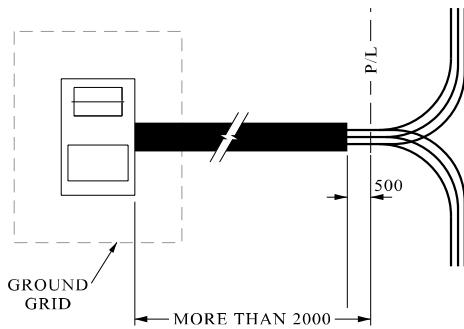
TERMINATION OF DUCT BANK AT
PROPERTY / EASEMENT LINE

JDE KITS:
 N/A

REVISION 1:
FONT CHANGED

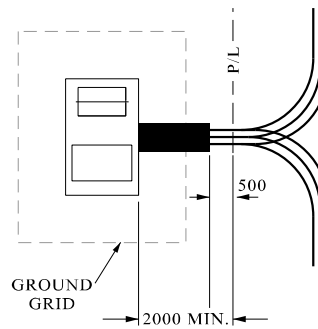
CHECKED BY: G.S.
APPROVED BY: P.K.

FIG. 1
FOUNDATION MORE THAN
2.0 m FROM PROPERTY LINE (P/L)



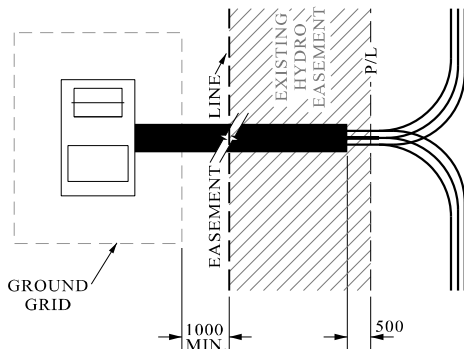
PRIMARY DUCT BANK REQUIRED

FIG. 2
FOUNDATION 2.0 m MIN.
FROM PROPERTY LINE (P/L)



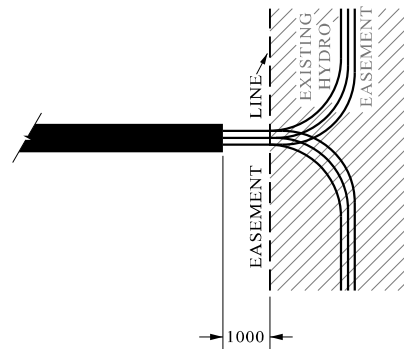
PRIMARY DUCT BANK REQUIRED

FIG. 3
EXISTING HYDRO EASEMENT
WITH NO CABLES



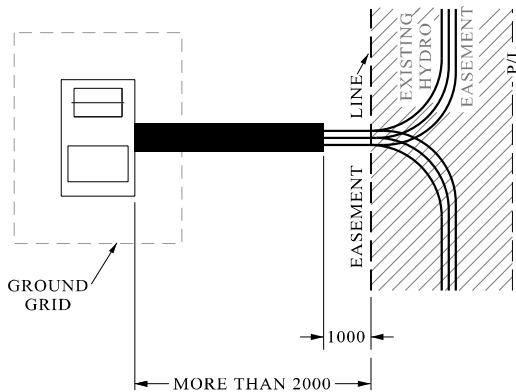
PRIMARY DUCT BANK REQUIRED
0.5 m FROM PROPERTY LINE (P/L)

FIG. 4
EXISTING HYDRO EASEMENT
WITH CABLES



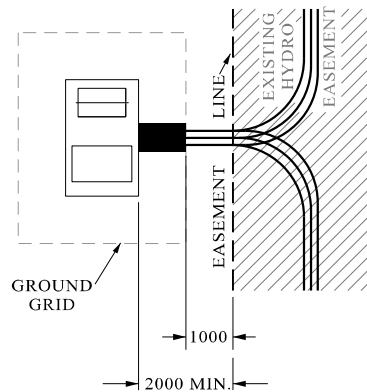
PRIMARY DUCT BANK REQUIRED
1.0 m FROM EASEMENT LINE

FIG. 5
EXISTING HYDRO EASEMENT
WITH CABLES AND FOUNDATION
MORE THAN 2.0 m FROM EASEMENT LINE



PRIMARY DUCT BANK REQUIRED
1.0 m FROM EASEMENT LINE

FIG. 6
EXISTING HYDRO EASEMENT
WITH CABLES AND FOUNDATION
2.0 m MIN. FROM EASEMENT LINE



PRIMARY DUCT BANK REQUIRED
1.0 m FROM EASEMENT LINE

ORIGINAL:
CHECKED BY : M.H.
APPROVED BY : D.C.

DATE : Jan-2001

TYPICAL DUCT BANK TERMINATION AT PROPERTY/EASEMENT LINE

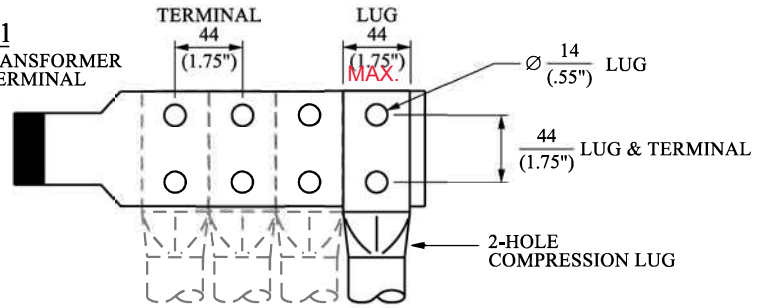
2.4/4.16 kV TO 16/27.6 kV

JDE KITS:
N/A

SERVICE SIZE	
1-PHASE, 3-WIRE	3-PHASE, 4-WIRE
200 A	200 A
400 A	400 A
600 A	600 A
	800 A
	1000 A
	1200 A
	1600 A
	2000 A
	2500 A
	3000 A

DETAIL 1

3-PHASE TRANSFORMER
BUSHING TERMINAL
(TYPICAL)

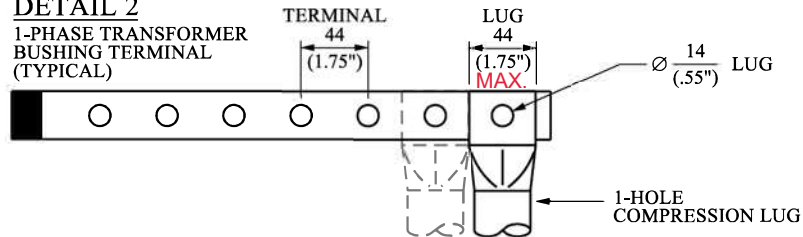


IMPORTANT!

HOLES AVAILABILITY MAY DEPEND ON TRANSFORMER SIZE (SEE NOTE 3)

DETAIL 2

1-PHASE TRANSFORMER
BUSHING TERMINAL
(TYPICAL)



NOTES:

- ABOVE IS A LIST OF SECONDARY SERVICE RATINGS MADE AVAILABLE FOR THE CUSTOMER
 - BASED ON THE CONDITIONS OF SERVICE, THE SECONDARY CABLES, CONNECTORS AND FASTENERS SHALL BE SUPPLIED AND INSTALLED BY THE CUSTOMER. ALECTRA LINES CREW IS REQUIRED TO BE ONSITE TO OPEN TRANSFORMER FOR CUSTOMER
 - THE CUSTOMER MUST COORDINATE THE NUMBER OF SECONDARY CABLES/PHASE WITH THE DESIGN TECH INVOLVED ON THE PROJECT IN ORDER NOT TO EXCEED THE ALLOWED CONNECTION (IN BACK-TO-BACK ARRANGEMENT) AT THE TRANSFORMER SECONDARY BUSHING
- BUSHING EXTENDER IS NOT PERMITTED TO ACCOMMODATE ADDITIONAL NUMBER OF SECONDARY CABLES. THEREFORE, THE FOLLOWING REQUIREMENTS ARE TO BE CONSIDERED:

TRANSFORMER SIZE, kVA	600Y/347 V (3-PH, 4-WIRE)	208Y/120 V (3-PH, 4-WIRE)	240/120 V (1-PH, 3-WIRE)
75 - 300 (3-PH), 75 - 167 (1-PH)	MAXIMUM 4 RUNS PER PHASE	MAXIMUM 4 RUNS PER PHASE	MAXIMUM 2 RUNS PER LINE
500	MAXIMUM 4 RUNS PER PHASE	MAXIMUM 8 RUNS PER PHASE	N/A
750	MAXIMUM 6 RUNS PER PHASE	N/A	N/A
1000 - 2500	MAXIMUM 8 RUNS PER PHASE	N/A	N/A
3000	MAXIMUM 10 RUNS PER PHASE	N/A	N/A

4. FOR PROPER ELECTRICAL CONNECTION, THE CUSTOMER IS RESPONSIBLE FOR THE FOLLOWING:

a) SECONDARY CABLES

- SHALL BE OF A TYPE, SIZE AND QUANTITY DESIGNED PER SERVICE SIZE, BE CSA APPROVED AND BE RECOGNIZED UNDER O.E.S.C.
- SHALL BE PROPERLY COILED INSIDE THE TRANSFORMER FOUNDATION AND BE LABELLED AT THE TRANSFORMER SECONDARY BUSHINGS (i.e. A/B/C OR R/W/B FOR 3-PHASE AND L1/L2/L0 FOR 1-PHASE OR EQUIVALENT)
- SHALL BE PROPERLY TRAINED AND TERMINATED TO MINIMIZE THE FORCE EXERTED ONTO TRANSFORMER SECONDARY BUSHINGS

b) CONNECTORS

- SHALL BE OF A TYPE MATCHING THE CONDUCTOR (i.e. COPPER TO COPPER, ALUMINUM TO ALUMINUM), HIGH CURRENT RATED AND TIN PLATED
- SHALL BE A COMPRESSION STYLE SECONDARY LUGS COMPATIBLE WITH CSA DIES FOR HEX-STYLE CRIMPING
- SHALL BE A 1-HOLE/ 2-HOLE N.E.M.A. SPADE MATCHING THE TRANSFORMER SECONDARY BUSHING TERMINAL ARRANGEMENT (SEE DETAIL 1 AND 2)

c) FASTENERS

- SHALL BE OF A SIZE 1/2" HEX BOLT AND ASSOCIATED HARDWARE (i.e. NUT, FLAT WASHER AND BELLVILLE WASHER)
- SHALL BE OF A TYPE AND LENGTH DESIGNED FOR ELECTRICAL (HIGH CURRENT) CONNECTION (REF. [STD. 15-182](#))

Certificate of Approval

The installation work covered by this standard meets the safety requirements of Section 4 of Regulation 22/04

Shereez Ali
Name

08/2020
Date

Signature
Signature & Professional Designation

P. Eng. PMP

ORIGINAL

Drawn by: Ar.C.
Checked by: P.D.
Approved by: A.F.
Date: Jul-2020

Title:

**INDUSTRIAL/COMMERCIAL
SECONDARY SERVICE REQUIREMENTS
(UP TO 3000 AMP SERVICE)**

1. GENERAL

This section covers the typical arrangement, installation and construction of Concrete Encased Duct Banks

All standards in this section are shown with minimum acceptable dimensions and materials. Underground system should be designed and constructed to provide adequate reliability and safety. Supply systems shall have ampacity adequate to operate under normal and emergency conditions without posing a risk to nearby facilities.

CONCRETE ENCASED DUCT BANK SYSTEM

Concrete encased duct bank installation provides mechanical protection to the underground cables from external forces. The external mechanical forces, that may damage the insulation of the cable, may consist of, but are not limited to water, insects/animals, and tree roots or mechanical “dig in” incidents. Such damages may lead to ground faults, outages, and other undesirable system conditions.

Duct banks are also installed to allow for less costly and easier conductor replacement. It is possible to replace a damaged, aged, or substandard cable in a duct bank with considerably less excavation. Alectra’s requirements for installing conductors in conduits or ducts, depend on a number of project factors which may include:

- Where conductors are located in a high-traffic area.
- Where conductors are installed in an area that is likely to have future excavations taking place.
- Where the conductor is crossing a roadway, highway or a railway.
- Where the conductor is of high significance (i.e. primary egress from a transformer station, key customer etc.).

2. Design Criteria

- 2.1 Deviations on a duct run shall be accomplished by a gradual sweep. All 90-degree changes in horizontal and vertical directions shall be made of 1500 mm (60”) radius elbows. The number of 90 degree bends shall be determined by pulling calculations.
- 2.2 The duct banks shall have a minimum cover of 900 mm (36”) throughout the top of the concrete shell and have a minimum slope of 1% away from the building. If the slope cannot be accomplished as described, please contact Alectra Utilities’ Designs Department to discuss alternatives (i.e. drain pit).
- 2.3 The duct bank shall be terminated below future soft landscaped area free of trees, bushes, or shrubs, at the location given by Alectra Utilities and be 1.0 m away from the property line or easement line. The area within 1.5 m from the face of the duct bank on either side shall be free of any foreign objects (i.e. cables, pipes, shoring etc.) within a property line. There shall be no object or structures on top or below of the duct bank within the easement area. This area shall be reserved for Alectra Utilities’ trenching, installation of cables and/or cable splices. The ductbank termination at property or easement line shall have maximum cover of 1.2 m.

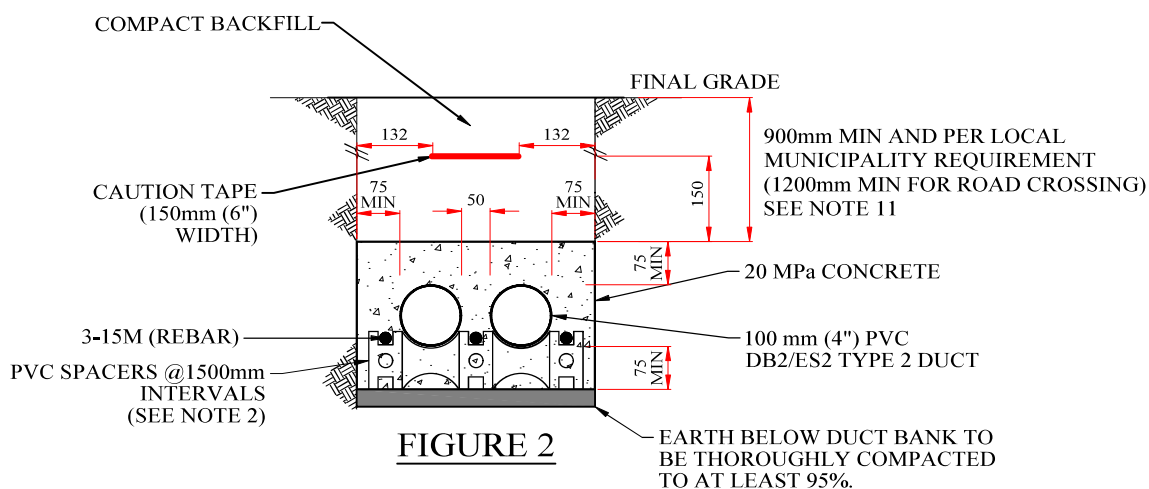
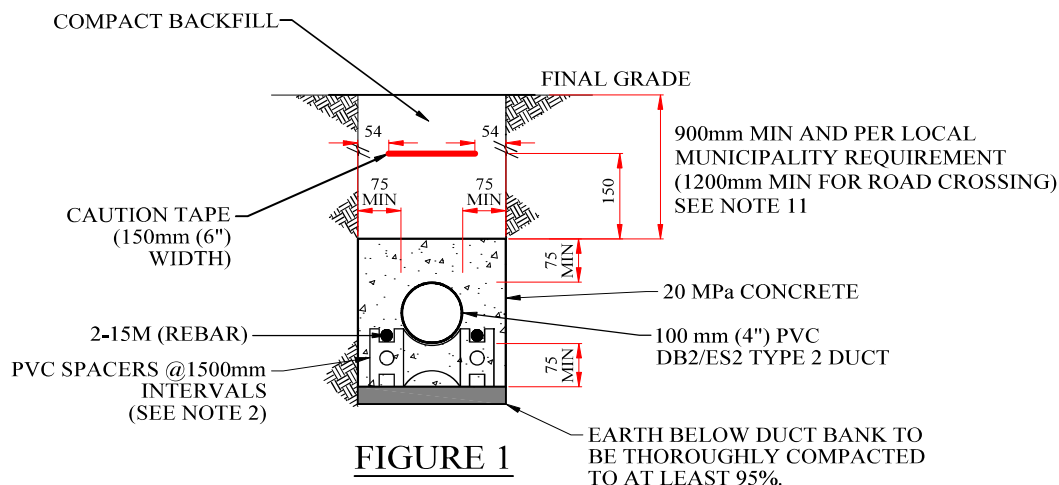
3. Duct Bank Construction

- 3.1 The ducts shall be 100 mm (4") diameter, PVC type DB2/ES2 (Solid Wall) and be CSA approved.
- 3.2 All ducts at the face of the duct bank, at property or easement line locations, shall be terminated with bell ends, capped with plastic plugs and to protrude 150 mm (6") from concrete encasement for Alectra Utilities' continuation (confirm with Alectra Utilities' Inspector).
- 3.3 All ducts at hydro equipment foundations and vault trenches shall be terminated with flush mounted bell ends.
- 3.4 All ducts at junction box and switchboard's wireway shall be terminated with bell ends. The bell ends shall have 1/2" spacing over concrete shell.
- 3.5 Where reinforcing bars enter buildings (i.e. transformer vault), bars are to enter full thickness of wall opening.
- 3.6 In a situation where the duct bank is not poured in one continuous run (i.e. driveway length, half & half), the reinforcing bars shall be made continuous from one duct bank to the other (with a minimum 1.0 m overlap).
- 3.7 All ducts shall be mandrelled, be cleaned after installation, and be equipped with polypropylene rope - minimum 3/8" diameter for service size up to 3000 AMP. In some installation, subject to the discretion of Alectra Utilities Inspector, it may require 3/4" mule tape with a minimum tensile strength of 2500 lbs.
- 3.8 All duct ends that require immediate covers shall be marked with a 2" x 4" x 6" stake at property line for later identification by Alectra Utilities.
- 3.9 Pouring the concrete is not permitted if the dry air temperature is less than minus five degrees Celsius (-5°) or more than thirty degrees Celsius (30°) unless otherwise instructed by an Alectra representative.
- 3.10 Concrete curing shall be as per CSA-A23.1. If the concrete will be poured during the winter season, the contractor shall submit for approval a proposal to keep the concrete temperature, during curing time, to be above ten degrees Celsius (10°) for the first 72 hours of concrete pouring.
- 3.11 If the vertical distance between the concrete shot and the bottom of the duct bank exceeds 1.5 m; it is recommended to use a concrete pump to avoid any concrete segregation unless otherwise instructed by an Alectra representative.
- 3.12 Due to possible presence of groundwater, the contractor may require the use of construction methods to maintain the hole dry during excavation and setting of the concrete which may include, but not limited to, casing the hole, drilling fluids, and/or dewatering.
- 3.13 Use a concrete vibrator during concrete pouring as per concrete vibrator manufacturer's recommendations.

- 3.14 The PVC pipe shall be joined together with an approved coupling, to provide a sound and watertight joint. The joints in adjacent ducts shall be staggered by at least 200mm.
- 3.15 For face of boulevard of 5m or more, duct bank shall be terminated 1.0m beyond the face of curb. If the face of boulevard is less than 5m, duct bank shall be terminated 0.5m beyond the face of curb
- 3.16 The Contractor shall supply and maintain approved ducts to permit the installation of the cables by Alectra Utilities Corporation.
- 3.17 Ducts located in the primary duct bank, required to provide electrical service to the customer, that are constructed, owned and maintained by the customer, are exclusive for the provision of distribution services for Alectra Only.
- 3.18 Ducts to be supported with Alectra Utilities approved spacers. The spacers shall be installed within 600mm on both sides where couplings are used.
- 3.19 A rebar located in the upper zone of duct bank might be required due to the following factors or conditions and would be typically designed by an engineer:
 - a. Soft soils, loose soils or soils that could be subjected to movement.
 - b. In special cases where the duct bank is located too close to the finished grade where adequate cover is not provided or difficult to achieve.
 - c. Under heavy vehicle traffic (industrial plants, rail yards etc.) top reinforcement and shear reinforcement maybe required.
 - d. Crossing of existing underground facilities.

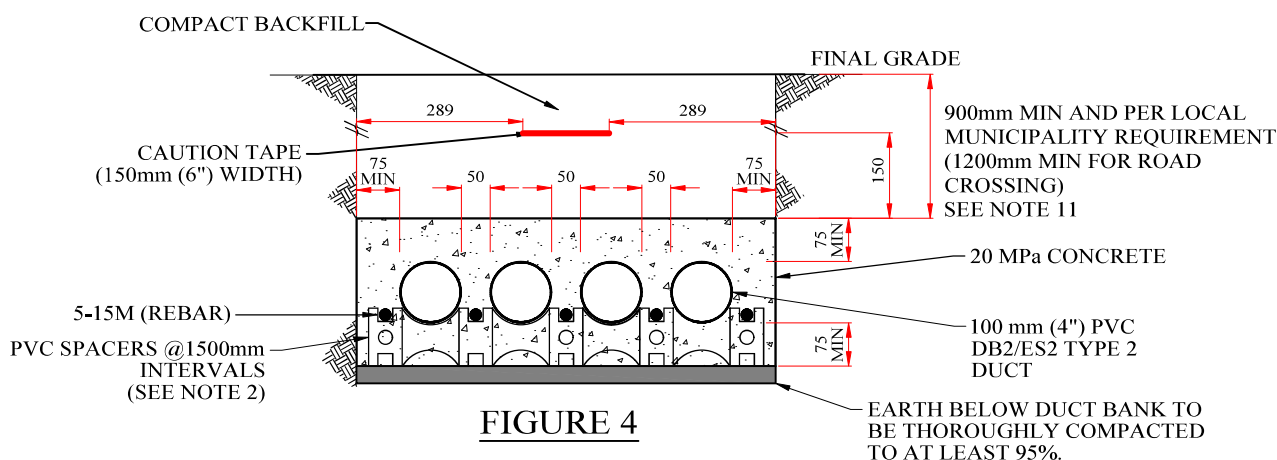
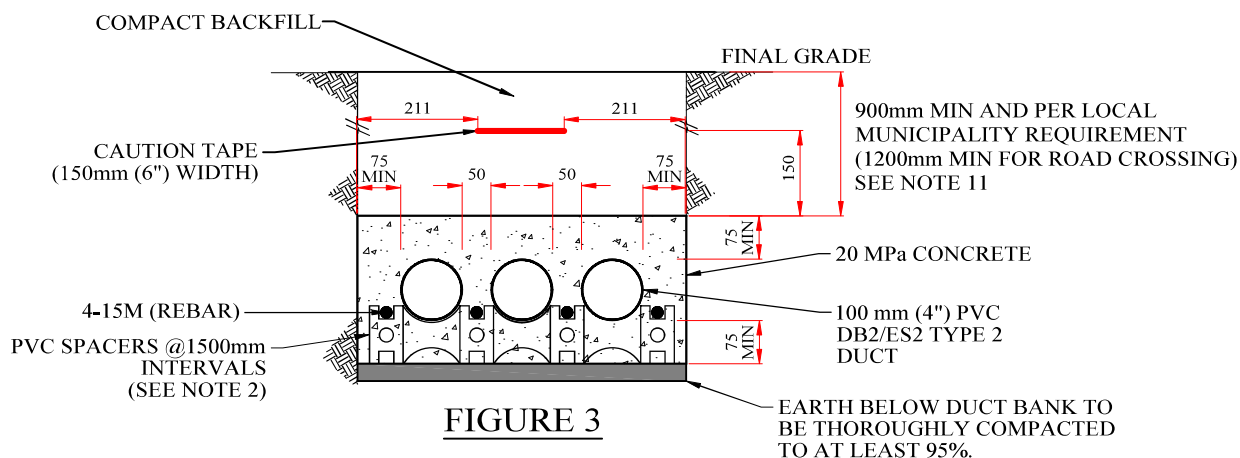
4. Customer Obligations

- 4.1 Customer's duct bank installation shall be subjected to Alectra Utilities inspection and acceptance prior to pouring of concrete. The Customer shall arrange the necessary inspection as per Alectra Utilities policies and procedures.
- 4.2 The Customer shall follow directions given by the Alectra Utilities Inspector or Project Design Technologist for any situation not covered in this specification.
- 4.3 All ducts must be probed prior to cable installation. The cables shall not be installed in ducts which do not allow passage of a mandrel sized to 95% of the diameter of the PVC Type DB2 / ES2.
- 4.4 Landscaping, paving and curbs installation/restoration shall not be completed until Alectra Utilities cable installation is complete. Otherwise, the Customer at their expense shall do all restorations.



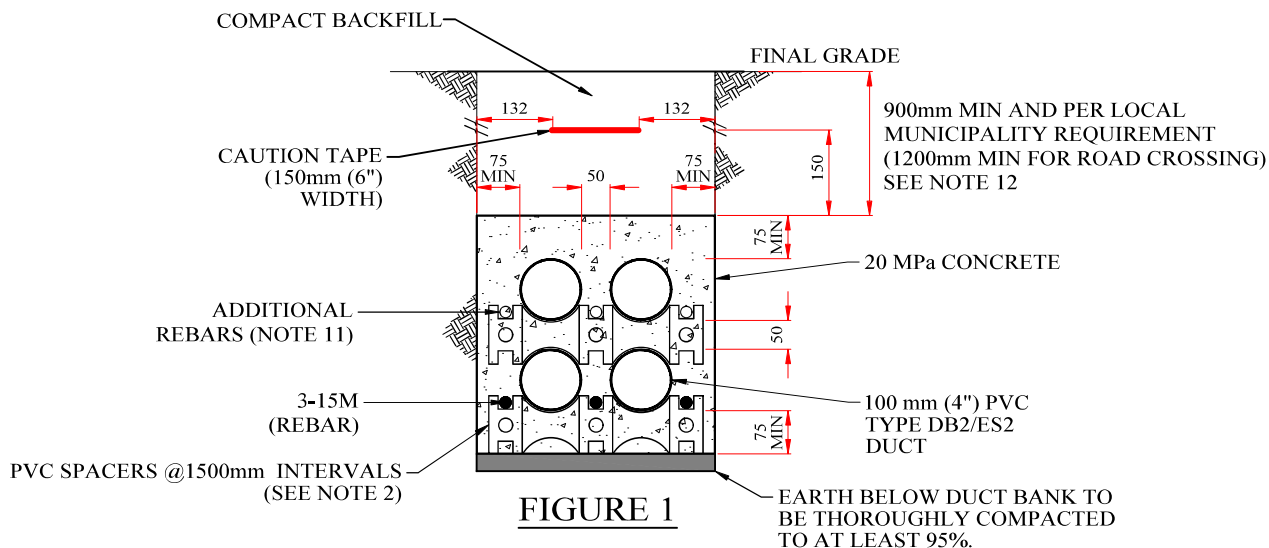
NOTES:

1. THE CAUTION TAPE SHALL BE A RED PLASTIC, 152 mm (6") WIDE x 0.1 mm (0.004") THICK C/W BLACK BOLD LETTERING "CAUTION BURIED ELECTRIC LINE BELOW" (ALECTRA ITEM #990242).
2. THE APPROVED 3 & 4-POSITION DUCT SPACERS ARE ROYAL CATALOGUE #DMB42233 & #DMB42234 (ALECTRA ITEMS #110654 & 110655). THE SPACERS SHALL BE PLACED AT 1500mm INTERVALS AND CUT TO SUIT THE DESIGN.
3. FOR GLUING DUCT JOINTS AND BENDS USE APPROVED S40 CEMENT AT LEAST 30 MINUTES PRIOR TO POURING CONCRETE.
4. DUCTS SHALL BE ENCASED IN 20 MPa CONCRETE WITH 10-20mm PEA GRAVEL AND SLUMP NOT TO EXCEED 100mm (4") UNDER STANDARD SLUMP TEST.
5. DUCT BANKS ALONG BOULEVARDS OR ACROSS ROADS SHALL HAVE BACKFILL MATERIALS AND TRENCH RESTORATION TO CONFORM WITH THE MUNICIPAL OR REGIONAL AUTHORITY, AS REQUIRED.
6. ALL DUCT BANKS SHALL BE REINFORCED WITH 15M(16mm) NON-PRESTRESSED DEFORMED STEEL REINFORCING BARS GRADE 400 (YIELD STRESS OF 413 MPa) AND CONFORM TO CSA G30.12 (LATEST REVISION). THE NUMBER PRECEDING THE REINFORCING BARS INDICATES THE QUANTITY OF REINFORCING BARS IN THAT ROW.
7. STEEL REINFORCING BARS SHALL BE INSTALLED CONTINUOUSLY, WITH A MINIMUM OF 600mm OVERLAP AND TIED TOGETHER. THE TIE-WIRE SHALL BE ANNEALED FERROUS WIRE, AS PER CSA-G30.14, ASTM A82/A82M-07.
8. DUCTS SHALL BE A MINIMUM 900mm BELOW GRADE AND IN ACCORDANCE WITH LOCAL MUNICIPAL GUIDELINES.
9. THIS STANDARD IS NOT TO BE USED FOR HIGHWAY OR RAILWAY CROSSINGS.
10. THIS DESIGN IS APPLICABLE TO A FAIRLY GOOD UNDISTURBED SOIL-TYPE 3 OR BETTER. FOR SOIL TYPES THAT DO NOT MEET THIS REQUIREMENT APPROPRIATE GEOTECHNICAL STUDIES MUST BE COMPLETED.
11. DUCTS SHALL BE ROUTED TO AVOID RAILWAYS, UNDERGROUND STRUCTURES, CATCH BASINS AND PIPELINES.
12. TO MITIGATE DIFFERENTIAL SETTLEMENT DUE TO UNSTABLE SOILS, CONSULT CSA C22.3 NO. 7 LATEST REVISION CLAUSE A.4.5.4 FOR POSSIBLE SOLUTIONS IN ADDITION TO A GEOTECHNICAL ENGINEER'S ADVICE.
13. FOR DUCT BANKS ENTERING A BUILDING OR FOUNDATION WHERE A DIFFERENTIAL IN SETTLEMENT MAY OCCUR, THE DESIGN SHALL ENSURE PROPER SUPPORT BY ADDING RE-BARS.



NOTES:

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11. FOR ROAD CROSSING DESIGNS REBAR SHALL BE USED IN THE TOP MOST SPACER IN ADDITION TO THE REBAR SHOWN ABOVE IN THE BOTTOM MOST SPACER.
12. DUCTS SHALL BE ROUTED TO AVOID RAILWAYS, UNDERGROUND STRUCTURES, CATCH BASINS AND PIPELINES.
13. TO MITIGATE DIFFERENTIAL SETTLEMENT DUE TO UNSTABLE SOILS, CONSULT CSA C22.3 NO. 7 LATEST REVISION CLAUSE A.4.5.4 FOR POSSIBLE SOLUTIONS IN ADDITION TO A GEOTECHNICAL ENGINEER'S ADVICE.
14. FOR DUCT BANKS ENTERING A BUILDING OR FOUNDATION WHERE A DIFFERENTIAL IN SETTLEMENT MAY OCCUR, THE DESIGN SHALL ENSURE PROPER SUPPORT BY ADDING RE-BARS.

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Materials and components for dry type transformers up to 600 V primary, equipment identification and transformer installation.

1.2 REFERENCES

- 1.2.1 ANSI/ASHRAE/IES Standard 90.1-2013 – Energy Standard for Buildings Except Low-Rise Residential Buildings.
- 1.2.2 CSA Group:
 - 1.2.2.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.2.2.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.2.2.3 CSA C22.2 No. 47-13 (R2018), Air-cooled transformers (dry type).
 - 1.2.2.4 CSA C9-17, Dry-type transformers.
 - 1.2.2.5 CSA C802.2-18, Minimum Efficiency Values for Dry-Type Transformers.
- 1.2.3 National Electrical Manufacturers Association (NEMA):
 - 1.2.3.1 NEMA ST-20-2014, Dry-Type Transformers for General Applications: sound levels.
- 1.2.4 NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment (published by the International Electrical Testing Association).
- 1.2.5 Ontario Building Code and its referenced standards.

1.3 ACTION SUBMITTALS

- 1.3.1 Product Data: Provide outline and support point dimensions of enclosures and accessories, unit weight, voltage, power, and impedance ratings and characteristics, tap configurations, insulation system type, and rated temperature rise.

1.4 INFORMATIONAL SUBMITTALS

- 1.4.1 Test Reports: Indicate loss data, efficiency at 25, 50, 75, and 100 per cent rated load, and sound level.
- 1.4.2 Submit manufacturer's installation instructions.
 - 1.4.2.1 Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements.
 - 1.4.2.2 Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Record actual locations of transformers in project record documents.
- 1.5.2 Document test results from NETA ATS.
- 1.5.3 Copies of completed factory reports and testing reports.

1.6 DELIVERY, STORAGE, AND HANDLING

- 1.6.1 Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations.
 - 1.6.2 Store so condensation will not form on or in the transformer housing and if necessary, apply temporary heat where required to obtain suitable service conditions. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
-

- 1.6.3 Handle to manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.
- 1.6.4 Handle transformer using proper equipment for lifting and handling, use when necessary lifting eye and/or brackets provided for that purpose.

1.7 WARRANTY

- 1.7.1 The transformer shall carry a 1 year warranty from the time of substantial performance.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 Transformers shall be standard general purpose dry type unless otherwise indicated on drawings as K-Rated or Harmonic Mitigation type.
- 2.1.2 Use transformers of one manufacturer throughout project and in accordance with CSA C22.2 No. 47 and CSA C9.

2.2 MANUFACTURERS

- 2.2.1 Manufacturer List:
 - 2.2.1.1 Bemag.
 - 2.2.1.2 Delta Transformer.
 - 2.2.1.3 Eaton.
 - 2.2.1.4 Hammond.
 - 2.2.1.5 Powersmiths.
 - 2.2.1.6 Rex Power Magnetics.
 - 2.2.1.7 Siemens.
 - 2.2.1.8 Schneider Electric.
 - 2.2.1.9 STI.
- 2.2.2 Substitutions: permitted if approved by the Consultant prior to Tender closing date.

2.3 REGULATORY REQUIREMENTS

- 2.3.1 Products: Listed and classified by CSA (Canadian Standards Association).
- 2.3.2 Efficiency ratings:
 - 2.3.2.1 Meet or exceed the efficiency levels indicated in CSA C802.2-12, and ASHRAE 90.1-2013, Table 8.4.4.

2.4 GENERAL PURPOSE TRANSFORMERS

- 2.4.1 NEMA ST-20, factory-assembled, air cooled low-inrush dry type transformer, ratings and voltages as indicated on drawings.
 - 2.4.2 Single or three phase as indicated on drawings.
 - 2.4.3 Type: AN/AA ventilated self-cooled.
 - 2.4.4 Copper or Aluminum windings.
 - 2.4.5 Finish: Final coating to be ANSI 61 Grey Epoxy Powder.
 - 2.4.6 T-connected transformers are not acceptable.
 - 2.4.7 Isolate core and coil from enclosure using vibration-absorbing mounts.
 - 2.4.8 Impedance: standard (3% to 5% nominal for up to 75 kVA, 4% to 6% for transformers 112.5 kVA and greater).
-

2.5 K-FACTOR RATED TRANSFORMERS

2.5.1 Provide where indicated on drawings.

2.6 PRIMARY VOLTAGE

2.6.1 600 volts delta, 3 phase;

2.6.2 480 volts delta, 3 phase.

2.7 SECONDARY VOLTAGE

2.7.1 347/600 volts, 3 phase wye;

2.7.2 277/480 volts, 3 phase wye;

2.7.3 120/208 volts, 3 phase wye.

2.8 INSULATION SYSTEM AND AVERAGE WINDING TEMPERATURE RISE

2.8.1 1-15 kVA: Class 185 with 150°C rise.

2.8.2 16-500 kVA: Class 220 with 150°C rise.

2.8.3 Above 500 kVA: Class 220 with 150°C rise.

2.9 CASE TEMPERATURE

2.9.1 Limits in accordance with CSA C22.2 No. 47.

2.10 WINDING TAPS

2.10.1 To NEMA ST-20.

2.10.2 Four full capacity 5 per cent adjustment taps, 2 at 2.5 per cent FCBN (full capacity below nominal) and 2 at 2.5 per cent FCAN (full capacity above nominal).

2.11 BASIC IMPULSE LEVEL

2.11.1 10 kV BIL.

2.12 GROUNDING

2.12.1 Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

2.13 MOUNTING

2.13.1 1-15 kVA: suitable for wall mounting.

2.13.2 16-75 kVA: suitable for wall, or floor, as shown.

2.13.3 Larger than 75 kVA: suitable for floor mounting.

2.14 COIL CONDUCTORS

2.14.1 Continuous windings with terminations brazed or welded.

2.15 ENCLOSURE

2.15.1 NEMA ST-20, CSA type 2 ventilated, sprinkler-proof. Provide lifting eyes or brackets.

2.15.2 CSA type 3R for outdoor locations.

2.16 CATCHER/DRIP BASE PLATE

2.16.1 Constructed from galvanized steel sheet metal having the minimum thickness as that of the transformer's enclosure.

- 2.16.2 To be provided for all transformers that are wall mounted, or suspended off the floor.

2.17 SOUND LEVELS

- 2.17.1 To NEMA ST-20 for transformers up to 300 kVA:
- 2.17.1.1 Up to 9 kVA: 40 dB.
 - 2.17.1.2 10 – 50 kVA: 45 dB.
 - 2.17.1.3 51 – 150 kVA: 50 dB.
 - 2.17.1.4 151 – 300 kVA: 55 dB.
- 2.17.2 Sound levels 3 dB less than NEMA ST-20 for transformers 301 kVA and greater:
- 2.17.2.1 301 – 500 kVA: 57 dB.
 - 2.17.2.2 501 – 700 kVA: 59 dB.
 - 2.17.2.3 701 – 1000 kVA: 61 dB.
 - 2.17.2.4 Above 1000 kVA: 3 dB less than NEMA ST-20.

2.18 NAMEPLATE

- 2.18.1 Transformer shall have embossed aluminum or stainless steel nameplate indicating, but not restricted to the following:
- 2.18.1.1 kVA rating.
 - 2.18.1.2 Voltage rating.
 - 2.18.1.3 Impedance.
 - 2.18.1.4 Type.
 - 2.18.1.5 Insulation class.
 - 2.18.1.6 Temperature rise.
 - 2.18.1.7 Connection diagram.
 - 2.18.1.8 Serial number.

2.19 EQUIPMENT IDENTIFICATION

- 2.19.1 Provide equipment identification in accordance with Section 26 05 53.

2.20 SOURCE QUALITY CONTROL

- 2.20.1 Production test each unit according to NEMA ST-20.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Mounting:
- 3.1.1.1 Mount dry type transformers up to 75 kVA, on floor, wall, or suspended from ceiling, as indicated on plans.
 - 3.1.1.2 Maintain clear space as described in 2021 OESC Rule 2-312.
 - 3.1.1.3 Mount dry type transformers rated above 75 kVA on floor.
 - 3.1.1.4 For wall mounted transformers, provide rubber-in-shear isolation mounts above bracket-supported rails secured from the wall.
 - 3.1.1.5 For ceiling mounted transformers, provide trapeze hangers and provide rubber-in-shear isolation mounts.
 - 3.1.1.6 Where a transformer is wall mounted or suspended off the floor, provide a metal catcher/drip base plate, and bolt to the bottom of the transformer below the base channel to conform to CSA C22.2 No. 47. Install in accordance with transformer manufacturer's instructions and recommendations.
 - 3.1.1.7 Mount floor mounted transformers on concrete housekeeping pads, minimum 100 mm (4") thick, and extending a minimum of 150 mm (6") beyond the footprint of the transformer.
-

- 3.1.1.8 Mount vibration isolating pads suitable for isolating the transformer noise from the building structure in accordance with Section 26 05 48.13.
- 3.1.2 Provide seismic restraints in accordance with Section 26 05 48.16.
- 3.1.3 Set transformer plumb and level.
- 3.1.4 Use flexible conduit, under the provisions of Section 26 05 33.13, 600 mm minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- 3.1.5 Provide grounding and bonding to Section 26 05 26.
- 3.1.6 Ensure adequate clearance around transformer for ventilation.
- 3.1.7 Install transformers in level upright position.
- 3.1.8 Remove shipping supports only after transformer is installed and just before putting into service.
- 3.1.9 Loosen isolation pad bolts until no compression is visible.
- 3.1.10 Make primary and secondary connections in accordance with wiring diagram.
- 3.1.11 Energize transformers after installation is complete.

3.2 FIELD QUALITY CONTROL

- 3.2.1 Section 01 45 00: Field Inspection, Testing, Adjusting.
- 3.2.2 Perform inspections and tests listed in NETA ATS, Section 7.2.

3.3 ADJUSTING

- 3.3.1 Measure primary and secondary voltages and make appropriate tap adjustments.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Distribution Switchboards rated 600 V and less.
- 1.1.2 Switchboard accessories.
- 1.1.3 Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for distribution switchboards as required for the complete performance of the work, and as shown on the Drawings and as herein specified.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 03 30 00 – Cast-in-Place Concrete: Concrete for supporting foundations and pads.
- 1.2.2 Section 25 96 00 – Integrated Automation Control Sequences for Electrical Systems.
- 1.2.3 Section 26 21 16 – Low-Voltage Underground Electrical Service Entrance.
- 1.2.4 Section 26 22 13 – Low-Voltage Distribution Transformers.
- 1.2.5 Section 26 27 13 – Electricity Metering.
- 1.2.6 Section 26 28 16.02 – Molded Case Circuit Breakers.
- 1.2.7 Section 26 43 13 – Surge Protective Devices for Low-Voltage Electrical Power Circuits.
- 1.2.8 Section 26 24 16 – Panelboards.

1.3 REFERENCES

- 1.3.1 ANSI C39.1 – Requirements for Electrical Analog Indicating Instruments.
 - 1.3.2 ASTM (ASTM):
 - 1.3.2.1 ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."
 - 1.3.3 CSA Group:
 - 1.3.3.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.3.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.3.3 CSA C22.2 No. 4-16, Enclosed and dead-front switches.
 - 1.3.3.4 CSA C22.2 No. 5-16, Molded case circuit breakers, molded case switches, and circuit-breaker enclosures.
 - 1.3.3.5 CSA C22.2 No. 144.1-16, Ground-fault circuit interrupters.
 - 1.3.3.6 CSA C22.2 No. 244:19, Switchboards.
 - 1.3.3.7 CSA Z462:21, Workplace electrical safety.
 - 1.3.3.8 CSA Z463-18, Maintenance of electrical systems.
 - 1.3.4 Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1.3.4.1 ANSI/IEEE C57.13, "Standard Requirements for Instrument Transformers" (copyrighted by IEEE, ANSI approved).
 - 1.3.5 InterNational Electrical Testing Association (NETA):
 - 1.3.5.1 NETA ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
 - 1.3.6 International Organization for Standardization (ISO):
 - 1.3.6.1 ISO 9001, Quality Management Systems - Requirements.
 - 1.3.7 National Electrical Contractors Association (NECA):
 - 1.3.7.1 NECA 400, "Standard for Installing and Maintaining Switchboards" (copyrighted by NECA, ANSI approved).
 - 1.3.8 National Electrical Manufacturers Association (NEMA):
-

- 1.3.8.1 NEMA AB 1 - Molded Case Circuit Breakers, Molded Case Switches, and Circuit - Breaker Enclosures.
- 1.3.8.2 NEMA C12.1 - Electric Meters; Code for Electricity Metering.
- 1.3.8.3 NEMA EI 21.1, "Instrument Transformers for Revenue Metering (110 kV BIL and Less)."
- 1.3.8.4 NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 volts Maximum).
- 1.3.8.5 NEMA PB 2 - Deadfront Distribution Switchboards.
- 1.3.8.6 NEMA PB 2.1 - Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 volts or Less.
- 1.3.8.7 NEMA 260 - Safety Labels for Pad Mounted Switchgear and Transformers Sited in Public Areas.
- 1.3.9 Ontario Building Code and its referenced standards.
- 1.3.10 Underwriters Laboratories, Inc. (UL):
 - 1.3.10.1 UL 1283, "Standard for Safety for Electro-Magnetic Interference Filters" (copyrighted by UL, ANSI approved).

1.4 PRE-INSTALLATION MEETINGS

- 1.4.1 Conduct pre-installation meeting in accordance with Section 01 31 19.
- 1.4.2 Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Consultant.

1.5 ACTION SUBMITTALS

- 1.5.1 Section 01 33 00: Procedures for submittals.
- 1.5.2 Work of this Section is to be submitted for review after Consultant's review of Coordination Study per Section 26 05 73.16 is completed.
- 1.5.3 Product Data:
 - 1.5.3.1 Provide electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of all equipment and components.
 - 1.5.3.2 Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications. Submit product data for each type of switchboard, overcurrent protective device, surge protective device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- 1.5.4 Shop Drawings:
 - 1.5.4.1 Indicate front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, and ground; and switchboard instrument details.
 - 1.5.4.2 Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer's standard product data. Submit shop drawings for each switchboard and related equipment.
 - 1.5.4.3 Indicate front and side enclosure elevations with overall dimensions, conduit entrance locations and requirements, nameplate legends, one-line diagrams, equipment schedule and switchboard instrument details.
- 1.5.5 Submit mimic-bus diagram.
- 1.5.6 The following information shall be submitted to the Consultant:
 - 1.5.6.1 Master drawing index.

- 1.5.6.2 Front view elevation.
- 1.5.6.3 Floor plan.
- 1.5.6.4 Top view.
- 1.5.6.5 Single line.
- 1.5.6.6 Schematic diagram.
- 1.5.6.7 Nameplate schedule.
- 1.5.6.8 Component list.
- 1.5.6.9 Conduit entry/exit locations.
- 1.5.6.10 Assembly ratings including:
 - (1) Short-circuit rating.
 - (2) Voltage.
 - (3) Continuous current.
- 1.5.6.11 Major component ratings including:
 - (1) Voltage.
 - (2) Continuous current.
 - (3) Interrupting ratings.
 - (4) Cable terminal sizes.
 - (5) Product data sheets.
- 1.5.6.12 Where applicable, the following additional information shall be submitted to the Consultant:
 - (1) Busway connection.
 - (2) Connection details between close-coupled assemblies.
 - (3) Composite floor plan of close-coupled assemblies.
 - (4) Key interlock scheme drawing and sequence of operations.
- 1.5.7 Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.
- 1.5.8 Quality Control Submittals:
 - 1.5.8.1 Test Reports: Submit field quality control test reports.
- 1.5.9 Upon review by the Consultant, submit switchboard shop drawings to the local electrical utility for their review and approval.

1.6 INFORMATIONAL SUBMITTALS

- 1.6.1 Section 01 33 00: Submittals for Information.
- 1.6.2 The following submittals are informational; responsive action by the Consultant is not required.
- 1.6.3 Test Reports: Indicate results of factory production tests.
- 1.6.4 Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.7 CLOSEOUT SUBMITTALS

- 1.7.1 Section 01 77 00: Submittals for Project Closeout.
 - 1.7.2 Operation and Maintenance Data:
-

- 1.7.2.1 Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.
- 1.7.2.2 Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.
- 1.7.3 Thermographic survey report.
- 1.7.4 Warranty Documentation: Submit manufacturer's standard warranty documents.
- 1.7.5 Record Documentation: Record actual locations of switchboard in project record documents.
- 1.7.6 Training session attendance records.
- 1.7.7 The following information shall be submitted for record purposes:
 - 1.7.7.1 Final as-built drawings and information shall incorporate all changes made during the manufacturing process.
 - 1.7.7.2 Wiring diagrams.
 - 1.7.7.3 Certified production test reports.
 - 1.7.7.4 Installation information.
 - 1.7.7.5 Seismic certification and equipment anchorage details as specified.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- 1.8.1 To Section 01 77 00.
- 1.8.2 Spare Parts: Provide four of each key.

1.9 QUALITY ASSURANCE

- 1.9.1 Manufacturer Qualifications:
 - 1.9.1.1 The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
 - 1.9.1.2 For the equipment specified herein, the manufacturer shall be ISO 9001 or ISO 9002 certified.
 - 1.9.1.3 The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Consultant, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- 1.9.2 Installer Qualifications:
 - 1.9.2.1 Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing switchboards similar in type and scope to that required for this Project.
- 1.9.3 Inspecting and Testing Agency Qualifications:
 - 1.9.3.1 To qualify for acceptance, an independent inspecting and testing agency hired by the Contractor or manufacturer to test products shall demonstrate to the Consultant's satisfaction that they are qualified according to ASTM E 329 to conduct testing indicated.
- 1.9.4 Certifications:
 - 1.9.4.1 Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.
 - 1.9.4.2 Comply with applicable requirements of the referenced standards.

1.10 DELIVERY, STORAGE, AND HANDLING

- 1.10.1 Section 01 60 00: Transport, Handle, Store, and Protect Products.
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- 1.10.2 Specify shipping split requirements where unusual obstructions, corridor configurations, or door widths will interfere with switchboard handling at site.
- 1.10.3 Deliver in 1219 mm (48 in) maximum width shipping splits, individually wrapped for protection and mounted on shipping skids.
- 1.10.4 Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- 1.10.5 Handle to NEMA PB 2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.
- 1.10.6 Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.
- 1.10.7 Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
- 1.10.8 Equipment shall be handled and stored in accordance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.11 WARRANTY

- 1.11.1 Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, or up to eighteen months from date of shipment.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Manufacturer List:
 - 2.1.1.1 Square D by Schneider Electric
 - 2.1.1.2 Eaton (Cutler-Hammer).
 - 2.1.1.3 Siemens.
- 2.1.2 Substitutions: Not permitted.
- 2.1.3 Product Options: The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Consultant ten (10) days prior to bid date.

2.2 GENERAL SWITCHBOARD REQUIREMENTS

- 2.2.1 Description: NEMA PB 2 switchboard with electrical ratings and configurations as indicated and specified.
 - 2.2.2 Regulatory Requirements
 - 2.2.2.1 Products certified by CSA Group, or testing firm acceptable to the Authority Having Jurisdiction as suitable for the purpose specified and indicated.
 - 2.2.3 Ratings:
 - 2.2.3.1 Voltage: 600 V.
 - 2.2.3.2 Configuration: Three phase, three wire, grounded.
 - 2.2.3.3 Main Bus: As per Single Line Diagrams.
 - 2.2.4 Ground Bus: Extend length of switchboard.
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- 2.2.5 Molded Case Circuit Breakers: To Section 26 28 16.02 – Molded Case Circuit Breakers.
- 2.2.6 Ground fault trip, zero sequence type ground fault sensor.
 - 2.2.6.1 Instantaneous trip.
 - 2.2.6.2 Adjustable short time trip.
 - 2.2.6.3 Stationary mounting or drawout construction, as applicable.
 - 2.2.6.4 Include shunt trip where indicated.
- 2.2.7 Line and Load Terminations: Accessible from the front only of the switchboard, suitable for the conductor materials and sizes indicated.
- 2.2.8 Ground Fault Sensor: Zero sequence type.
- 2.2.9 Ground Fault Relay: Adjustable ground fault sensitivity from 200 A to 1200 A, time delay adjustable from 0 to 15 seconds. Provide monitor panel with lamp to indicate relay operation, TEST and RESET control switches.
- 2.2.10 Ground Fault Sensor: Zero sequence type.
- 2.2.11 Ground Fault Relay: Adjustable ground fault sensitivity from 200 A to 1200 A, time delay adjustable from 0 to 15 seconds. Provide monitor panel with lamp to indicate relay operation, TEST and RESET control switches.
- 2.2.12 Incoming entry: As noted on plans.
- 2.2.13 Incoming location: As noted on plans.
- 2.2.14 Branch Circuit Entry: Top.
- 2.2.15 Silver Flashed Copper.
- 2.2.16 Minimum Interrupt Rating: 65 kA.
- 2.2.17 Bus Bracing Rating: 65 kA.
- 2.2.18 Solid Bottom Plates.
- 2.2.19 Box Finish - ASA 61 (Std).
- 2.2.20 Trim Finish - ASA 61 (Std).
- 2.2.21 Silver Flashed Copper Ground Bus.
- 2.2.22 Vermin proof.
- 2.2.23 Channel Sills.
- 2.2.24 Refer to Single Line Diagram for additional information.

2.3 SHORT CIRCUIT RATINGS

- 2.3.1 The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current 65 000 amperes symmetrical at rated voltage or as indicated on the drawings.
- 2.3.2 Use fully rated overcurrent devices. Series ratings will not be accepted.

2.4 CONSTRUCTION

- 2.4.1 The entire assembly shall be front accessible and shall consist of main lugs or main device as shown on the plans.
- 2.4.2 Feeder devices 150 A frame through 1200 A frame shall be panel-mounted-type construction. Devices over 1200 A frame or main devices shall be individually mounted when required.

2.5 BUS

- 2.5.1 All bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65°C over a 40°C ambient (outside the enclosure).
-

- 2.5.2 A copper ground bus (minimum 1/4 in by 2 in), shall be furnished firmly secured to each vertical section structure, and shall extend the entire length of the switchboard.
- 2.5.3 Copper neutral bus.
- 2.5.4 All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

2.6 WIRING/TERMINATION

- 2.6.1 Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.
- 2.6.2 Mechanical-type terminals shall be provided for all line and load terminations suitable for copper or aluminum cable rated for 90°C of the size as indicated on the drawings.
- 2.6.3 Lugs shall be provided in the incoming line section for connection of the main grounding conductor. Additional lugs for connection of other grounding conductors shall be provided as indicated on the drawings.
- 2.6.4 All control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle-type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

2.7 ENCLOSURE

- 2.7.1 Provide CSA type 2 steel enclosure complete with sprinklerproof drip shield.
- 2.7.2 Align sections at front and rear.
- 2.7.3 Switchboard Height: 2286 mm (90 in), excluding floor sills, lifting members and pull boxes.
- 2.7.4 Section depths: as per drawings.
- 2.7.5 Section widths: as per drawings.

2.8 ENCLOSURE FINISH

- 2.8.1 All exterior and interior steel surfaces of the switchboard shall be properly cleaned and provided with a factory applied rust-inhibiting phosphatized coating. Colour and finish of the switchboard shall be ANSI 61 light gray.
- 2.8.2 Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.

2.9 BARRIERS

- 2.9.1 Provide barriers between adjacent switchboard sections.

2.10 INSULATION AND ISOLATION

- 2.10.1 Provide taped bus for through bus.

2.11 FRONT COVERS

- 2.11.1 Front covers shall be screw removable with a single tool and doors shall be hinged with removable hinge pins.
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2.12 BUS TRANSITION AND INCOMING PULL SECTIONS

- 2.12.1 Match and align with basic switchboard.

2.13 PULL BOX ON TOP OF SWITCHBOARD

- 2.13.1 Provide adequate ventilation to maintain temperature in pull box within same limits as switchboard.
- 2.13.2 Set back from front to clear circuit breaker removal mechanism.
- 2.13.3 Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
- 2.13.4 Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
- 2.13.5 Lace cables using industry-approved methods.

2.14 FEEDER ENTRY

- 2.14.1 Coordinate busway or cable feeder entry requirements with Single Line Diagram.
- 2.14.2 Provide busway flange to suit busway feeders.

2.15 FUTURE DEVICES

- 2.15.1 Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit breaker compartment.
- 2.15.2 Fully equip spaces for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Provide continuous current rating as indicated.

2.16 METERING AND INSTRUMENTATION

- 1.1.1 Utility Metering Compartment: Provide fabricated compartment and section complying with utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
- 1.1.2 Instrumentation for Owner's metering:
 - 1.1.2.1 Instrument Transformers: NEMA EI 21.1, ANSI/IEEE C57.13, and the following:
 - 1.1.2.1.1 Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - 1.1.2.1.2 Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
 - 1.1.2.1.3 Control Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
 - 1.1.2.2 Multifunction Digital Metering Monitor: Microprocessor-based unit suitable for three-wire or four-wire systems and with the following features:
 - 1.1.2.2.1 Digital Display: Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - 1.1.2.2.2 Phase Currents, Each Phase: ± 1 percent.
 - 1.1.2.2.3 Phase-to-Phase Voltages, 3-Phase: ± 1 percent.
 - 1.1.2.2.4 Phase-to-Neutral Voltages, 3-Phase: ± 1 percent.
 - 1.1.2.2.5 Megawatts: ± 2 percent.
 - 1.1.2.2.6 Megavars: ± 2 percent.

- 1.1.2.2.7 Power Factor: ± 2 percent.
- 1.1.2.2.8 Frequency: ± 0.5 percent.
- 1.1.2.2.9 Megawatt Demand: ± 2 percent; demand interval programmable from 5 to 60 minutes.
- 1.1.2.2.10 Accumulated Energy, Megawatt Hours: ± 2 percent. Accumulated values unaffected by power outages up to 72 hours.
- 1.1.2.2.11 Watt-Hour Meters: Flush or semi-flush type, rated 5 A, 120 V, three-phase, three-wire, with three elements, 15 minute-indicating-demand register, and provision for testing and adding pulse initiation.
- 1.1.2.2.12 Recording Demand Meter: Usable as totalizing relay or as indicating and recording maximum demand meter with 15 minute interval. Meter shall count and control a succession of pulses entering two channels.
- 1.1.2.2.13 Mounting: Display and control unit flush or semi-flush mounted in instrument compartment or main device door.
- 1.1.2.3 Interface with other systems: Provide BACnet gateway for connection to Building Automation per Section 25 96 00.

2.17 MIMIC BUS

- 2.17.1 Provide an anodized aluminum or plastic engraved plaque. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic bus diagram. Produce a concise visual presentation of principal switchboard components and connections.
- 2.17.2 Show bussing, connections, and devices in single line form on the front panels of the switchboard using blue colour light metal strips, fastened flat against the panel face with screws or rivets.

2.18 NAMEPLATES

- 2.18.1 Lamacoid nameplates to Section 26 05 53:
 - 2.18.1.1 Switchboard nameplate.
 - 2.18.1.2 Branch circuit nameplates.
- 2.18.2 Engraved nameplates, mounted on the face of the assembly, shall be furnished for all main and feeder circuits as indicated on the drawings. Nameplates shall be laminated plastic, black characters on white background. Characters shall be 3/16 in high, minimum. Nameplates shall give item designation and circuit number as well as frame ampere size and appropriate trip rating. Furnish master nameplate giving switchboard designation, voltage ampere rating, short-circuit rating, manufacturer's name, general order number, and item number.

2.19 GROUND FAULT PROTECTION

- 2.19.1 Furnish and install in the service equipment and/or switchboard ground fault protection and indication equipment as shown on drawings in accordance with 2021 OESC 14-102. All parts of the systems specified shall be CSA certified. All new ground fault protection and indication equipment shall be factory installed, wired, and tested by the switchboard manufacturer.

2.20 SOURCE QUALITY CONTROL

- 2.20.1 Section 01 45 00: Manufacturer quality control.
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- 2.20.2 Shop inspect, and test switchboard according to NEMA PB 2.
- 2.20.3 Allow witnessing of factory inspections and tests at manufacturer's test facility. Notify Consultant at least 7 days before inspections and tests are scheduled.
- 2.20.4 The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of ANSI and NEMA standards.
 - 2.20.4.1 The switchboard shall be completely assembled, wired, adjusted, and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 V for one (1) minute between live parts and ground and between opposite polarities. The wiring and control circuits shall be given a dielectric test of 1500 V for one (1) minute between live parts and ground.
 - 2.20.4.2 Perform factory and installation tests in accordance with applicable OESC, NEMA and CSA requirements.
- 2.20.5 The manufacturer shall provide three (3) certified copies of factory test reports.
- 2.20.6 A certified test report of all standard production tests shall be available to the Consultant upon request.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Consultant, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
- 3.1.2 Verify that field measurements are as indicated on shop drawings.
- 3.1.3 Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

3.2 PREPARATION

- 3.2.1 Provide concrete housekeeping pad to Section 03 30 00 and Section 26 05 29.

3.3 INSTALLATION

- 3.3.1 General
 - 3.3.1.1 Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer's written recommendations, and as indicated on the Drawings.
 - 3.3.1.2 Install switchboards and accessories according to NEMA PB 2.1 and NECA 400.
 - 3.3.1.3 Install and anchor switchboards level on concrete bases, 100 mm (4 in) nominal thickness. Concrete base is specified in Section 26 05 29, and concrete materials and installation requirements are specified in Division 03.
 - 3.3.1.4 Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
 - 3.3.1.5 Frame and mount the printed basic operating instructions for switchboards, including, but not limited to, control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
 - 3.3.1.6 Install overcurrent protective devices, surge protective devices, and instrumentation.

- (1) Set field-adjustable switches and circuit breaker trip ranges.
- 3.3.1.7 Install spare fuse cabinet.
- 3.3.2 Install switchboard in locations shown on drawings, according to CSA C22.1.
- 3.3.3 Tighten accessible bus connections and mechanical fasteners after placing switchboard.
- 3.3.4 Install fuses in each switch.
- 3.3.5 Install all equipment per the manufacturer's recommendations and the contract drawings.
- 3.3.6 The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to Contractor supplied floor sills to be set level in concrete per manufacturer's recommendations the floor without the use of floor sills providing the floor is level to 1/8 in per 3 ft distance in any direction. All necessary hardware to secure the assembly in place shall be provided by the Contractor.
- 3.3.7 Examine substrates and conditions in which units will be installed. Check for clearance that will be required before, during and after equipment installation. Do not proceed with installation until unsatisfactory conditions are corrected.
- 3.3.8 Strictly comply with manufacturer's instructions and recommendations and NEMA PB 2.1. Coordinate installation with adjacent work to ensure proper sequence of construction, clearances, and support.
- 3.3.9 Install units plumb, level, and rigid without distortion to the switchboard cubicle(s).
- 3.3.10 Identification
 - 3.3.10.1 Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 26 05 53.
 - 3.3.10.2 Label each switchboard compartment with engraved metal or laminated plastic nameplate mounted with corrosion-resistant screws.
 - 3.3.10.3 Arc Flash Warning Labels
 - (1) Refer to Section 26 05 73.19.
 - (2) Apply in the field, the arc flash warning label to all switchboards to suit future examination, adjustment, servicing, or maintenance while energized to warn qualified persons of potential electrical arc flash hazards.

3.4 FIELD QUALITY CONTROL

- 3.4.1 Section 01 45 00: Quality Assurance.
- 3.4.2 Perform inspections and tests listed in NETA ATS, Section 7.1.
- 3.4.3 Prepare for acceptance tests as follows:
 - 3.4.3.1 Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 3.4.3.2 Test continuity of each circuit.
- 3.4.4 Perform the following field tests and inspections and prepare test reports:
 - 3.4.4.1 Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.
 - 3.4.4.2 Perform infrared thermographic survey in accordance with NETA ATS, Section 9 "Thermographic Survey". Submit report to the Consultant.
 - 3.4.4.3 Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.5 PROTECTION

- 3.5.1 Provide final protection and maintain conditions in a manner that shall ensure that the switchboards shall be without damage at time of Substantial Performance.
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3.6 ADJUSTING

- 3.6.1 Section 01 77 00: adjusting installed work.
- 3.6.2 Adjust all operating mechanisms for free mechanical movement.
- 3.6.3 Tighten bolted bus connections to manufacturer's instructions.
- 3.6.4 Adjust circuit breaker trip and time delay settings to values indicated as instructed by the Consultant.
- 3.6.5 Coordination Study Labels and Field Adjustment
 - 3.6.5.1 Refer to Section 26 05 73.16.
 - 3.6.5.2 The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short-circuit study, protective device evaluation study and protective device coordination study.
 - 3.6.5.3 Necessary field settings of devices, adjustments, and minor modifications to equipment to accomplish conformance with an approved short-circuit and protective device coordination study, shall be carried out by the Contractor at no additional cost to the Owner.

3.7 CLEANING

- 3.7.1 Section 01 74 19: cleaning installed work.
- 3.7.2 Clean exposed surfaces using manufacturer recommended materials and methods.
- 3.7.3 Touch-up damaged coatings and finishes using non-abrasive materials and methods recommended by manufacturer. Eliminate all visible evidence of repair.
- 3.7.4 Touch up scratched or marred surfaces to match original finish.

3.8 TRAINING

- 3.8.1 The Contractor shall provide a training session for up to five (5) Owner's representatives for normal workdays at a jobsite location determined by the Owner.
- 3.8.2 A manufacturer's qualified representative shall conduct the training session. The training program shall consist of instruction on the operation of the assembly, circuit breakers, fused switches, meters, and major components within the assembly.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Power distribution panelboards – Circuit breaker type.
- 1.1.2 Lighting and appliance branch circuit panelboards.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 28 16.02 – Molded Case Circuit Breakers.
- 1.2.2 Section 26 43 13 – Surge Protective Devices for Low-Voltage Electrical Power Circuits: externally mounted surge protective devices.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 5-16 – Molded Case Circuit Breakers, molded-case switches, and circuit-breaker enclosures.
 - 1.3.1.4 CSA C22.2 No. 29-15 – Panelboards and Enclosed Panelboards.
- 1.3.2 NEMA:
 - 1.3.2.1 NEMA ICS 2-2000 (R2020) – Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 volts.
 - 1.3.2.2 NEMA KS 1-2013 – Heavy Duty Enclosed and Dead-Front Switches (600 volts Maximum).
 - 1.3.2.3 NEMA PB 1-2011 – Panelboards.
 - 1.3.2.4 NEMA PB 1.1-2013 – General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 volts or Less.
- 1.3.3 NETA ATS – Acceptance Testing Specifications for Electrical Power Distribution Equipment (published by the International Electrical Testing Association).

1.4 SUBMITTALS

- 1.4.1 Submit in accordance with Section 01 33 00.
- 1.4.2 Work of this Section is to be submitted for review after Consultant's review of Coordination Study per Section 26 05 73.16 is completed.
- 1.4.3 Shop drawings shall contain overall panelboard dimensions, interior mounting dimensions, and wiring gutter dimensions. The location of the main, branches, and solid neutral shall be clearly shown. In addition, the drawing shall illustrate one line diagrams with applicable voltage systems.
- 1.4.4 Shop drawings:
 - 1.4.4.1 Indicate the following:
 - (1) Outline and support point dimensions.
 - (2) Voltage.
 - (3) Main bus ampacity.
 - (4) Integrated short circuit ampere rating.
 - (5) Circuit breaker arrangement, types, and sizes.
 - 1.4.4.2 The following information shall be submitted to the Consultant:
 - (1) Breaker layout drawing with dimensions indicated and nameplate designation.

- (2) Component list.
 - (3) Conduit entry/exit locations.
 - (4) Assembly ratings including:
 - (A) Short-circuit rating.
 - (B) Voltage.
 - (C) Continuous current.
 - (5) Cable terminal sizes.
 - (6) Product data sheets.
- 1.4.4.3 Where applicable, the following additional information shall be submitted to the Consultant:
 - (1) Key interlock scheme drawing and sequence of operations.
- 1.4.5 Submittals for Construction
 - 1.4.5.1 The following information shall be submitted for record purposes:
 - (1) Installation information.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Refer to Section 01 77 00.
- 1.5.2 Record actual locations of panelboards and record actual circuiting arrangements in project record documents.
- 1.5.3 Maintenance Data: Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.
- 1.5.4 Final as-built drawings and information shall incorporate all changes made during the manufacturing and installation process.
- 1.5.5 Include a copy of each panelboard schedule in the Operation and Maintenance manual.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- 1.6.1 Manufacturer shall provide installation instructions and NEMA Standards Publication PB 1.1 – Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 volts or Less.
- 1.6.2 Equipment operation and maintenance manuals shall be provided with each assembly shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists where applicable, for the complete assembly and each major component.
- 1.6.3 Provide two of each panelboard key.
- 1.6.4 Provide final panelboard schedules indicating panelboard data, phasing, breaker sizes, and loads served.

1.7 QUALITY ASSURANCE

- 1.7.1 Regulatory Requirements
 - 1.7.1.1 Products: Listed and classified by CSA (Canadian Standards Association).
 - 1.7.2 Qualifications
 - 1.7.2.1 Company specializing in manufacturing of panelboard products with a minimum of 20 years' experience.
 - 1.7.2.2 The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
 - 1.7.2.3 For the equipment specified herein, the manufacturer shall be ISO 9001 or 9002 certified.
-

- 1.7.2.4 The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Consultant, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.8 DELIVERY, STORAGE, AND HANDLING

- 1.8.1 Inspect and report concealed damage to carrier within their required time period.
- 1.8.2 Handle carefully to avoid damage to panelboard internal components, enclosure, and finish.
- 1.8.3 Store in a clean, dry environment. Maintain factory packaging and, if required, provide an additional heavy canvas or heavy plastic cover to protect enclosure(s) from dirt, water, construction debris, and traffic.
- 1.8.4 Equipment shall be handled and stored in accordance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.9 WARRANTY

- 1.9.1 Warrant specified equipment to be free from defects in materials and workmanship for eighteen (18) months from the date of purchase.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 Description: CSA C22.2 No. 29, circuit breaker type.

2.2 DISTRIBUTION PANELBOARDS – CIRCUIT BREAKER TYPE

- 2.2.1 Manufacturers:
 - 2.2.1.1 Square D by Schneider Electric, I-LINE Series.
 - 2.2.1.2 Eaton Cutler-Hammer, PRL 3 and PRL4 Series.
 - 2.2.1.3 Equal by Siemens.
- 2.2.2 The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Consultant ten days prior to bid date.
- 2.2.3 Panelboard Bus:
 - 2.2.3.1 Copper, ratings as indicated.
 - 2.2.3.2 Provide copper neutral bus for panelboards indicated for 4-wire systems.
 - 2.2.3.3 Provide copper ground bus in each panelboard.
- 2.2.4 Short Circuit Ratings:
 - 2.2.4.1 Panelboards rated 600 V shall have minimum integrated short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 65 000 amperes RMS symmetrical.
 - 2.2.4.2 Distribution panelboards with bolt-on devices contained therein shall have interrupting ratings as specified herein or indicated on the drawings.
 - 2.2.4.3 Panelboards shall be fully rated.
 - 2.2.4.4 Where indicated, provide circuit breakers ULC listed for application at 100 per cent of their continuous ampere rating in their intended enclosure.
- 2.2.5 Minimum integrated short circuit rating: Panelboards rated 240 V shall have minimum integrated short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 10 000 amperes RMS symmetrical.

- 2.2.6 Molded Case Circuit Breakers: To Section 26 28 16.02.
- 2.2.7 Circuit Breaker Accessories: Trip units and auxiliary switches as indicated.
- 2.2.8 Cabinet Front: Surface type, fastened hinge and latch, metal directory frame, finished in manufacturer's standard gray enamel.
- 2.2.9 Enclosures: CSA type 2 sprinklerproof complete with drip hood, or as noted.
- 2.2.10 Trims shall be equipped with a flush lock.
- 2.2.11 Breaker positions labeled as "Spare" or "Space" shall constitute no less than 20 per cent of available breaker positions, whether indicated or not in panelboard schedules.
- 2.2.12 Each panel shall be complete with a directory which shall be mounted inside door in a metal frame with clear plastic cover and copy in each Data Book. Use final Room Numbers for directories.

2.3 BRANCH CIRCUIT PANELBOARDS

- 2.3.1 Manufacturers:
 - 2.3.1.1 Square D by Schneider Electric, NQ or NQOD Series.
 - 2.3.1.2 Eaton Cutler-Hammer, POW-R-LINE 1, POW-R-LINE 2, POW-R-LINE 3 Series.
 - 2.3.1.3 Equal by Siemens.
 - 2.3.2 Description: CSA C22.2 No.29, circuit breaker type, lighting and appliance branch circuit panelboard.
 - 2.3.3 Panelboard Bus:
 - 2.3.3.1 Copper, ratings as indicated.
 - 2.3.3.2 Provide copper neutral bus in each panelboard.
 - 2.3.3.3 Provide copper ground bus in each panelboard.
 - 2.3.3.4 Provide insulated ground bus where scheduled.
 - 2.3.4 Minimum Integrated Short Circuit Rating: 10 000 amperes RMS symmetrical for 240 V panelboards, or as indicated.
 - 2.3.5 Molded Case Circuit Breakers: NEMA AB 1, plug-on type thermal magnetic trip circuit breakers, with common trip handle for all poles, listed as Type SWD for lighting circuits, Type HACR for air conditioning equipment circuits, Class A ground fault interrupter circuit breakers where scheduled. Do not use tandem circuit breakers.
 - 2.3.6 Current Limiting Molded Case Circuit Breakers where indicated: NEMA AB 1, circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.
 - 2.3.7 Cabinet Front: Surface cabinet front with concealed trim clamps, concealed hinge, metal directory frame, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.
 - 2.3.8 Enclosure shall be CSA type 2 sprinklerproof complete with drip hood, or as noted.
 - 2.3.9 Trims shall be equipped with a flush lock.
 - 2.3.10 Breaker positions labeled as "Spare" or "Space" shall constitute no less than 20 per cent of available breaker positions, whether indicated or not in panelboard schedules.
 - 2.3.11 Panelboards: to CSA C22.2 No.29 and product of one manufacturer.
 - 2.3.11.1 Install circuit breakers in panelboards before shipment.
 - 2.3.11.2 In addition to CSA requirements manufacturer's nameplate must show fault current that panel including breakers has been built to withstand.
 - 2.3.12 Panelboards rated 240 VAC or less shall have short-circuit ratings as shown on the drawings or as herein scheduled, but not less than 10,000 amperes RMS symmetrical.
-

- 2.3.13 Bus and breakers rated for symmetrical interrupting capacity, as indicated.
 - 2.3.14 Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.
 - 2.3.15 Panelboards: mains, number of circuits, and number and size of branch circuit breakers as indicated.
 - 2.3.16 Two keys for each panelboard and key panelboards alike.
 - 2.3.17 Copper bus with neutral of same ampere rating as mains.
 - 2.3.18 Mains: suitable for bolt-on breakers.
 - 2.3.19 Trim with concealed front bolts and hinges.
 - 2.3.20 Trim and door finish: baked grey enamel.
 - 2.3.21 The minimum short-circuit rating for branch circuit panelboards shall be as specified herein or as indicated on the drawings. Panelboards shall be fully rated.
 - 2.3.22 Bolt-on type, heavy-duty, quick-make, quick-break, single- and multi-pole circuit breakers of the types specified herein, shall be provided for each circuit with toggle handles that indicate when unit has tripped.
 - 2.3.23 Circuit breakers shall be thermal-magnetic type with common type handle for all multiple pole circuit breakers. Circuit breakers shall be minimum 100 A frame and through 100 A trip sizes shall take up the same pole spacing. Circuit breakers shall be ULC listed as type SWD for lighting circuits.
 - 2.3.23.1 Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management, and control system (EMCS) panels and fire alarm panels.
 - 2.3.24 Circuit breakers shall have a minimum interrupting rating of 10 000 A symmetrical at 240 V, and 14 000 amperes symmetrical at 480 V, unless otherwise noted on the drawings.
 - 2.3.25 Each panel shall be complete with a directory which shall be mounted inside door in a metal frame with clear plastic cover and copy in each Data Book. Use final Room Numbers for directories.
 - 2.3.26 Panels shall be dead front type in code gauge steel enclosures. All panels shall be sprinkler proof c/w drip hoods as required.
 - 2.3.27 Panels shall have mains of voltage and capacity, and main and branch breakers, as shown on the drawings. Spaces shall include necessary bus work such that Owners, at a later date, need buy only the breakers.
 - 2.3.28 Where panels exceed 66 circuits, use multi-section panel with main cross-over solid bus bars unless noted otherwise on drawings. Main bus capacity of each section shall be full size to match cross-over bus.
 - 2.3.29 Breakers shall have bolted type connections. Multi-pole breakers shall be common trip type with a single handle, suitable for voltage applied and of same manufacture as single pole breakers.
 - 2.3.30 Panels for 120/208 V, 3-phase, 4-wire systems shall be complete with full size breakers.
 - 2.3.31 Where shown on drawings or required by code, certain breakers shall include ground fault interrupter.
 - 2.3.32 Provide lighting and receptacle panels suitable for surface, or flush-mounting type, as shown.
 - 2.3.33 Provide locking bars on non-switched circuits where panels are used for switching lighting circuits.
 - 2.3.34 Panels for non-linear loads shall be complete with lugs for double neutrals.
 - 2.3.35 Panels shall be given a rust-resistant treatment to both tub and trim.
-

- 2.3.36 Flush panels shall have concealed hinges and flush type combination lock latch. Locks shall be chrome plated. Doors shall open minimum 135 degrees. Trims shall have fasteners concealed and shall be prime coated to receive room finish paint.
- 2.3.37 Surface mounted panels shall have manufacturer's standard surface door trim complete with lock and latch. Finish shall be grey.
- 2.3.38 Recessed panels shall have standard flush trims.
- 2.3.39 Co-ordinate panel finish with Room Finish Schedule.

2.4 MOLDED CASE CIRCUIT BREAKERS

- 2.4.1 Breakers: to Section 26 28 16.02.
- 2.4.2 Breakers with thermal and magnetic tripping in panelboards except as indicated otherwise.
- 2.4.3 Main breaker: separately mounted on top or bottom of panel to suit cable entry. When mounted vertically, down position should open breaker.
- 2.4.4 Lock-on devices for 10 per cent of 15 A to 30 A breakers installed as indicated. Turn over unused lock-on devices to Owner.
- 2.4.5 Lock-on devices for fire alarm, security, and sprinkler circuits.
- 2.4.6 Provide shunt trips, bell alarms, and auxiliary switches as shown on the contract drawings.
- 2.4.7 Provide breakers for externally mounted Surge Protective Devices in accordance with Section 26 43 13.

2.5 CONSTRUCTION

- 2.5.1 General:
 - 2.5.1.1 Interiors shall be completely factory assembled. They shall be designed such that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors.
 - 2.5.1.2 Surface trims shall be same height and width as box. Flush trims shall overlap the box by 3/4 of an inch on all sides.
 - 2.5.1.3 A temporary directory card with a clear plastic cover shall be supplied and mounted on the inside of each door.
 - 2.5.1.4 All locks shall be keyed alike.
- 2.5.2 Branch Circuit Panelboards:
 - 2.5.2.1 Trims for branch circuit panelboards shall be supplied with a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a semi flush cylinder lock and catch assembly. Door-in-door trim shall be provided. Both hinged trim and trim door shall utilize three point latching. No tools shall be required to install or remove trim. Trim shall be equipped with a door-actuated trim locking tab. Equip locking tab with provision for a screw such that removal of trim requires a tool, at the owner's option. Installation shall be tamper resistant with no exposed hardware on the panelboard trim.
- 2.5.3 Distribution Panelboards:
 - 2.5.3.1 Distribution panelboard trims shall cover all live parts. Switching device handles shall be accessible.

2.6 BUS

- 2.6.1 Lugs: Copper and listed by CSA, or cUL, for use with copper conductors and sized to accept copper conductors of the ampacity specified.
-

- 2.6.2 Main bus bars shall be copper sized in accordance with CSA standards to limit temperature rise on any current carrying part to a maximum of 65°C above an ambient of 40°C maximum.
- 2.6.3 A copper system ground bus shall be included in all panelboards.
- 2.6.4 Full-size (100 per cent rated) insulated copper neutral bars shall be included for panelboards shown with neutral. Bus bar taps for panels with single-pole branches shall be arranged for sequence phasing of the branch circuit devices. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection. 200 per cent rated neutrals shall be supplied for panels designated on drawings with oversized neutral conductors.

2.7 EQUIPMENT IDENTIFICATION

- 2.7.1 Provide equipment identification in accordance with Section 26 05 53.
- 2.7.2 Nameplate for each panelboard size 4 engraved.
- 2.7.3 Nameplate for each branch circuit in distribution panelboards size 2 engraved.
- 2.7.4 Complete circuit directory with typewritten legend showing location and load of each circuit.
- 2.7.5 Provide an engraved nameplate for each panelboard section.
- 2.7.6 Provide copies of all circuit directories in manuals.

2.8 SOURCE QUALITY CONTROL

- 2.8.1 The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of NEMA and CSA standards.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install panelboards to CSA C22.1.
 - 3.1.2 Install panelboards plumb.
 - 3.1.3 Height: 1800 mm to top of panelboard; install panelboards taller than 1800 mm with bottom no more than 100 mm above floor.
 - 3.1.4 Provide filler plates for unused spaces in panelboards.
 - 3.1.5 Provide typed circuit directory for each branch circuit panelboard. Revise directory to reflect circuiting changes required to balance phase loads.
 - 3.1.6 Provide engraved plastic nameplates under the provisions of Section 26 05 53.
 - 3.1.7 Ground and bond panelboard enclosure according to Section 26 05 26.
 - 3.1.8 Locate panelboards as indicated and mount securely, plumb, true, and square, to adjoining surfaces.
 - 3.1.9 Install surface mounted panelboards on fire rated plywood backboards in accordance with Section 26 05 29. Where practical, group panelboards on common backboard.
 - 3.1.10 Connect loads to circuits.
 - 3.1.11 Connect neutral conductors to common neutral bus with respective neutral identified.
 - 3.1.12 Deliver five (5) duplicate keys for each panel lock to the Owner.
 - 3.1.13 Mount electrical panels, where possible, with top of trim at uniform height of 2000 mm.
 - 3.1.14 Cap ends of conduits in accessible locations in ceiling spaces above panels, to allow for future wiring.
-

- 3.1.15 The Contractors shall install all equipment per the manufacturer's recommendations and the contract drawings.
- 3.1.16 Install panelboards in accordance with manufacturer's written instructions, NEMA PB 1.1 and Electrical Code requirements.
- 3.1.17 After completion of wiring, type directory showing a clear description of each circuit being controlled from panel and place in metal frame inside door.
- 3.1.18 Provide circuit breaker handle locks for all circuits that supply exit signs, emergency lights, energy management, and control system (EMCS) panels and fire alarm panels.

3.2 FIELD QUALITY CONTROL

- 3.2.1 Perform inspections and tests listed in NETA ATS, Section 7.4 for switches, Section 7.5 for circuit breakers.
- 3.2.2 Inspect complete installation for physical damage, proper alignment, anchorage, and grounding.
- 3.2.3 Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads within 20 per cent of each other. Maintain proper phasing for multi-wire branch circuits.
- 3.2.4 Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written specifications.

3.3 ADJUSTING

- 3.3.1 Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads to within 20 percent of each other.
- 3.3.2 Maintain proper phasing for multi-wire branch circuits.

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Supply, install and commission sub-meters along with current sensors and data loggers to measure specific electric loads as indicated on the drawings. The measured Voltages, Currents, Power Demands and Energy Consumptions shall be continuously uploaded to City of Mississauga servers for storage and future analysis.
 - 1.1.1.1 The number of meters, Current transformer (CT) and data loggers for each location is indicated on the drawings.
 - 1.1.1.2 The exact location for meters, CT's and data loggers to be confirmed on site prior to installation.
 - 1.1.1.3 Purchase the meters, CT's and data loggers (with the necessary power supply modules) as detailed in the schedule.
 - 1.1.1.4 Provide the necessary cables, enclosures, and conduits as per the specifications.
 - 1.1.1.5 LockOut – TagOut (LOTO) procedure for electrical work shall be followed to ensure adequate energy isolation.
 - 1.1.1.6 All meters and data loggers to be installed in separate enclosures – supplied by the contractor, and mounted on the walls.
 - 1.1.1.7 All cables to be run in conduits supplied by the contractor.
 - 1.1.1.8 Remove the designated panels' covers to reach the cables.
 - 1.1.1.9 Install the CT's on the designated cables.
 - 1.1.1.10 Run the CT's cables through conduits to the meter.
 - 1.1.1.11 Connect voltage sensing cables to the panel and run the cables to the meter through conduits.
 - 1.1.1.12 Connect the data logger power supply cables permanently to the nearest power supply source (120 VAC). Run the cables through conduits.
 - 1.1.1.13 Connect the Modbus communication cable between the meter and the data logger. Run the cable through conduit.
 - 1.1.1.14 Provide and connect Cat6A data cable between City of Mississauga provided network connection and the data logger.
 - 1.1.1.15 Attach all cable conduits to walls.
 - 1.1.1.16 Commission the system. Ensure accurate data is received at the data logger.
 - 1.1.1.17 Label all new meters, cables and CTs.
 - 1.1.1.18 Ensure that all panels and enclosures are covered.
 - 1.1.1.19 Restore power supply; Reinstate the site to initial condition prior the beginning of works.
 - 1.1.1.20 Prepare and submit the final set of documents that includes manuals and final commissioning reports.
 - 1.1.1.21 Obtain ESA certificate and submit to City of Mississauga.

1.2 REFERENCES

- 1.2.1 City of Mississauga Corporate Green Standard.

1.3 QUALITY ASSURANCE

- 1.3.1 Marking:
 - 1.3.1.1 The Electrical Meter shall be marked and comply with CE directives.
 - 1.3.1.2 The Electrical Meter shall be marked and comply with the CSA.
 - 1.3.1.3 The Electrical Meter shall be marked with UL.
- 1.3.2 The Electrical Meters shall comply with the following safety/construction standards:
 - 1.3.2.1 IEC61010-1 (EN61010-1): Safety requirements for electrical equipment for measurement, control and laboratory use.

- 1.3.2.2 CSA C22.2 No. 1010-1: Canadian Standards Association. Certified by Canadian Standards Association (CSA).
- 1.3.2.3 UL61010B-1 Measuring, Testing and Signal Generation Equipment
- 1.3.2.4 IEC62052-11: Electricity metering equipment (AC) – general requirements, tests and test conditions.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Submittal and approval of all commissioning/testing reports and ESA certificate.

2 PRODUCTS

2.1 MULTI-CIRCUIT ENERGY METERS

- 2.1.1 Manufacturers
 - 2.1.1.1 DENT Instruments PowerScout series.
 - 2.1.1.2 TRIACTA PowerHawk 4000 series with potential transformer.
 - 2.1.1.3 Equivalent subject to prior approval.
- 2.1.2 Mounting Configuration:
 - 2.1.2.1 Meters shall be mounted in separate enclosures on the wall near electrical cabins.
- 2.1.3 Service Types:
 - 2.1.3.1 Single Phase, Three Phase-Four Wire (WYE), Three Phase-Three Wire (Delta).
- 2.1.4 Voltage/Current Channels:
 - 2.1.4.1 Voltage: 3 Voltage Channels, 80-346 Volts AC Line-to-Neutral, 600 V Line-to-Line, CAT III.
 - 2.1.4.2 Current: 24 channels 0-5,000+ Amps depending on current transducer.
 - 2.1.4.3 Maximum Current Input: 200% of current transducer rating.
- 2.1.5 Measurement Type: True RMS using high-speed digital signal processing (DSP)
- 2.1.6 Line Frequency: 50/60 Hz.
- 2.1.7 Power: From L1 Phase to L2 Phase. 80-600 VAC CAT III 50/60 Hz, 200 mA max.
- 2.1.8 Power Out: Unregulated 5 VDC output, 500 mA max.
- 2.1.9 Waveform Sampling: 12 kHz.
- 2.1.10 Parameter Update Rate: 1 second.
- 2.1.11 Measurements: Volts, Amps, kW, kWh, kVAR, kVARh, kVA, kVAh, Apparent Power Factor (aPF), Displacement Power Factor (dPF). All parameters for each phase and for system total.
- 2.1.12 Accuracy: less than 1% for V, A, kW, kVAR, kVA, PF
- 2.1.13 Resolutions: Amp, 0.1 Volt, 0.01 watt, 0.01 VAR, 0.01 VA, 0.01 Power Factor depending on scalar setting.
- 2.1.14 Pulse Output: Open Collector, 75 mA max current, 40 V max open voltage
- 2.1.15 Communication:
 - 2.1.15.1 Direct:
 - (1) User Selectable Modbus RTU or BACnet Master Slave Token Passing protocol (MS/TP) RS-485 or Ethernet, and USB for meter setup.
 - 2.1.15.2 Serial Meters:
 - (1) Max Communication Length: 1200 meters with Data Range of 100 k bits/second or less.
 - (2) RS-485 Loading: 1/8 unit.

- (3) Communication Rate (baud): Modbus: 9600 (Default), 19200, 38400, 57600, 76800, 115200.
 - (4) BACnet: 9600 (Default), 19200, 38400, 76800.
 - (5) Data Bits: 8.
 - (6) Parity: None, Even, Odd.
 - (7) Stop Bit: 2, 1.
- 2.1.15.3 Data Formats
 - (1) Modbus Protocol or BACnet Master Slave / Token Passing (MS/TP) protocol.
- 2.1.16 Operating Temperature: -7°C to + 60°C (-20°F to 140°F).
- 2.1.17 Humidity: 5% to 95% non-condensing.
- 2.1.18 Safety:
 - 2.1.18.1 Serial/Ethernet Meters
 - (1) UL listed: PS24-D-S/PS24D-E
 - (2) UL Recognized: PS24-N-S/ PS24-N-E
 - (3) The PS24 Series:
 - (A) Conforms to UL Std 61010-1, 2nd Edition
 - (B) Certified to CSA Std C22.2 No. 61010-1, 2nd Edition.
 - (C) (CE does not apply to PS24 ethernet).

2.2 CURRENT TRANSFORMERS

- 2.2.1 Manufacturers:
 - 2.2.1.1 Dent Instruments Standard Current Transformers:
 - (1) Split Core CT or equivalent
 - (2) Hinged CT or equivalent
 - (3) RoCoil Flexible Rope CT or equivalent
 - 2.2.1.2 Equivalent products are subject to prior approval.
 - 2.2.1.3 Combination of the above is acceptable.
- 2.2.2 Rating: Properly rated based on metered load
- 2.2.3 Accuracy:
 - 2.2.3.1 Ratio Error: less 1%.
 - 2.2.3.2 Phase Error: less 2%.
- 2.2.4 Frequency Range: 50 Hz to 400 Hz.
- 2.2.5 Leads: Up to 500 ft. Subject to site conditions and the locations of meters and cables
- 2.2.6 Operating Temperature: -15° to 55°C (-4° to 131°F).
- 2.2.7 Working Voltage: 600 VAC, Category III.
- 2.2.8 Dielectric Strength:
 - 2.2.8.1 Minimum 3000 VAC around case
 - 2.2.8.2 Minimum 600 V rated leads.
- 2.2.9 Certification:
 - 2.2.9.1 Conforms to: UL STD 61010-1, EN 60044-1
 - 2.2.9.2 Certified to: CAN/CSA STD C22.2 No. 61010
 - 2.2.9.3 Marked with: CE and ETL or UL

2.3 ENCLOSURES

- 2.3.1 Meter manufacturer recommended.

2.4 DATA LOGGERS

2.4.1 References

2.4.1.1 Marking:

- (1) The Data Logger shall be marked and comply with CE directives.
- (2) The Data Logger shall be marked with UL.

2.4.1.2 The Data Logger shall comply with the following safety/construction standards:

- (1) CSA C22.2 No. 205-17 (R2022), Signal equipment: certified by Canadian Standards Association (CSA).
- (2) UL61010B-1, 2nd Measuring, Testing and Signal Generation Equipment.
- (3) FCC CFR 47 Part 15.
- (4) Class A.
- (5) EN 61000.
- (6) EN 61326.
- (7) CE.

2.4.2 Manufacturers:

- 2.4.2.1 AcquiSuite EMB A8810 with 120 VAC/24 VDC power supply.

2.4.3 Mounting Configuration:

- 2.4.3.1 Data logger and power supply module shall be mounted in the same enclosure on the wall near electrical panels.

2.4.4 Memory and data logging:

- 2.4.4.1 Minimum 32 MB RAM.
- 2.4.4.2 Minimum 16 MB NOR Flash ROM (expandable with USB memory device).
- 2.4.4.3 Interval Recording 1 to 60 minutes, user selectable (default 15 minutes).

2.4.5 Power:

- 2.4.5.1 Power Supply: 120 VAC.
- 2.4.5.2 Isolation: RJ45 Ethernet and RS-485 port shall be isolated to 1500 VDC from the main board.

2.4.6 Communication:

- 2.4.6.1 Protocols: Modbus/RTU, Modbus/TCP, TCP/IP, PPP, HTTP/HTML, FTP, NTP, XML, SNMP-Trap
- 2.4.6.2 LAN: RJ45 10/100 Ethernet, full half duplex, auto polarity
- 2.4.6.3 USB: USB expansion port

2.4.7 Inputs:

- 2.4.7.1 Serial Port RS-485 Modbus, supports up to 32 external devices (expandable)

2.4.8 Environment:

- 2.4.8.1 North America -30°C to 70°C, 95% RH, non-condensing

2.4.9 Enclosure

- 2.4.9.1 Data logger manufacturer recommended.

2.4.10 Power Supply

- 2.4.10.1 Data logger Manufacturer recommended.

2.4.10.2 Class:

- (1) Class 2.

2.4.10.3 Input:

(1) 120 VAC.

2.4.10.4 Output:

(1) 24 VDC.

(2) 500 mA to 8 A.

2.5 METERING COMMUNICATION CABLES

2.5.1 All Modbus network cables shall be Belden 1120A, shielded twisted pair, 18 AWG, 600 VAC or equivalent.

2.5.2 Provide BACnet gateway for connection to Building Automation System described in Division 25.

2.5.3 All Ethernet network wiring shall be CAT6A.

2.6 SCHEDULE OF POINTS

2.6.1 Main Electrical Utility Meter (pulse).

2.6.2 Domestic water meter (pulse).

2.6.3 Enbridge gas meter (pulse).

2.6.4 Other meter points as noted on the single line diagram.

3 EXECUTION

3.1 ACCEPTABLE INSTALLERS

3.1.1 Qualified electrical contractor to install all equipment.

3.2 INSTALLATION

3.2.1 Meters:

3.2.1.1 All power supply and communications wiring connections shall be performed in accordance with the guidelines set out in the meter product documentation.

3.2.1.2 All current and voltage sensing connections to the meter must be made using appropriately rated CT's and PT's.

3.2.1.3 Installation of meter and ancillary equipment, and wiring connections to all electrical circuits, other meters and terminal strips for external devices must comply with all Local and national Electrical Codes.

3.2.1.4 All voltage sensing connections to metering instrumentation shall be made with appropriately sized fuses.

3.2.1.5 All CTs shall be appropriately sized for the service.

3.2.1.6 Mount new meter, except where noted, in its own externally mounted enclosure.

3.2.1.7 Install labels to identify the meters IDs, the inputs and the CTs (identification of the measured load).

3.2.2 Data Loggers:

3.2.2.1 All power supply and communications wiring connections shall be performed in accordance with the guidelines set out in the data logger product documentation.

3.2.2.2 Installation of data logger and ancillary equipment, and wiring connections to all electrical circuits, other data logger and terminal strips for external devices must comply with all Local and national Electrical Codes.

3.2.2.3 All data loggers must be directly connected to the nearest 120 VAC power source.

3.2.2.4 Mount the data logger with its power supply in their own externally mounted enclosure.

3.2.2.5 Coordinate with data logger supplier and software provider for final software configuration and data logger commissioning.

3.2.2.6 Install labels to identify the ID of the data logger.

3.3 LABELLING

3.3.1 In accordance with Section 26 05 53.

3.3.2 Install labels and tags on the following locations:

3.3.2.1 Current Transformers: Label to indicate the identification of the measured load.

3.3.2.2 Meters:

(1) Label to indicate the meter ID.

(2) Labels to indicate inputs identification.

(3) Directory of input number and input name.

3.3.2.3 Data Logger: Label to indicate data logger ID.

3.3.3 Position labels clearly and consistently.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Electrical cabinets.
- 1.1.2 Electrical enclosures.
- 1.1.3 Splitters.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 27 26 – Wiring Devices.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 94.2:20 – Enclosures for Electrical Equipment, Environmental Considerations.
- 1.3.2 Underwriters Laboratories Inc. (UL):
 - 1.3.2.1 UL 50 – Enclosures for Electrical Equipment, Non-Environmental Considerations.
 - 1.3.2.2 UL 50E – Enclosures for Electrical Equipment, Environmental Considerations

1.4 SUBMITTALS

- 1.4.1 Comply with Section 01 33 00.
- 1.4.2 Product Data: Provide manufacturer's catalogue information showing dimensions, colours, and configurations.

1.5 QUALITY ASSURANCE

- 1.5.1 Manufacturer Qualifications: Products shall be free of defects in material and workmanship.
- 1.5.2 Furnished products shall be listed or classified by third party agencies as suitable for the intended purpose.

1.6 WARRANTY

- 1.6.1 Product is warranted free of defects in material and workmanship.
- 1.6.2 Product is warranted to perform the intended function within design limits.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 NEMA 12/4X screw cover enclosures.
- 2.1.2 NEMA 12/4X hidden hinge cover enclosures.
- 2.1.3 NEMA 12/4X external hinge cover enclosures.

2.2 MANUFACTURERS

- 2.2.1 Bel Products.
 - 2.2.2 EXM Manufacturing.
 - 2.2.3 Hammond Manufacturing.
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- 2.2.4 Hoffman.
- 2.2.5 Thomas & Betts.
- 2.2.6 Ralston Metal.

2.3 REGULATORY REQUIREMENTS

- 2.3.1 Provide products listed and classified by CSA (Canadian Standards Association).

2.4 DESIGN AND PERFORMANCE REQUIREMENTS

- 2.4.1 NEMA 12/4X screw cover enclosures:
 - 2.4.1.1 Enclosure shall be UL listed in accordance with UL-50 and CSA or cUL certified to CSA C22.2 No. 94.2.
 - 2.4.1.2 Enclosure shall have CSA enclosure ratings type 1, 2, 3, 3S, 3X, 3SX, 4, 4X and 12.
 - 2.4.1.3 Body shall be manufactured from a high-impact, corrosion resistant solid engineering thermoplastic material; UV stabilized for outdoor use and complies with UL-94 minimum V-2 requirements.
 - 2.4.1.4 Cover shall be manufactured from either a high-impact, corrosion resistant solid engineering material, UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements, or a clear polycarbonate material, UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements.
 - 2.4.1.5 Body and cover shall maintain physical properties through overall temperature range of -35°C to 110°C (-31°F to 230°F).
 - 2.4.1.6 Body shall be an industrial grey colour, and lid shall be either industrial grey or clear.
 - 2.4.1.7 Cover and body shall be free of rough corners, sharp edges, or burrs.
 - 2.4.1.8 Cover screws (10-32) shall be captive with a slotted stainless steel (type 304) fillister head.
 - 2.4.1.9 Factory installed brass inserts shall be provided for cover (10-32), mounting flanges (1/4-20), and panel mounting (10-32) screws.
 - 2.4.1.10 Mounting flanges shall be removable and shall permit vertical or horizontal placement on the body.
 - 2.4.1.11 Back panel mounting means shall accept standard size back panels.
 - 2.4.1.12 Interior body corners shall have dovetail to permit panel to be mounted at any depth.
 - 2.4.1.13 Swing out panel mounts shall be utilized when a second panel is desired, or when access to the rear of the primary panel is desired.
 - 2.4.1.14 Hardware kit for adjustable panel mounting shall be available.
 - 2.4.1.15 Hardware kit for swing out panel mounting shall be available.
 - 2.4.1.16 Enclosure gasket shall be oil resistant continuous closed cell neoprene.
 - 2.4.1.17 Enclosure body shall have tapered edges to keep liquids away from cover opening.
 - 2.4.1.18 Back panel shall be available in either 14 gauge steel, painted white, or in 7 mm (1/4 in) PVC.
 - 2.4.1.19 Enclosure shall be available as factory assembly or as individual components.
 - 2.4.2 NEMA 12/4X hidden hinge cover enclosures:
 - 2.4.2.1 Enclosure shall be UL listed in accordance with UL-50 and CSA or cUL certified to CSA C22.2 No. 94.2.
 - 2.4.2.2 Enclosure shall have CSA enclosure ratings type 1, 2, 3, 3S, 3X, 3SX, 4, 4X, and 12.
 - 2.4.2.3 Body shall be manufactured from a high-impact, corrosion resistant solid engineering thermoplastic material; UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements.
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- 2.4.2.4 Cover shall be manufactured from either a high-impact, corrosion resistant solid engineering material, UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements, or a clear polycarbonate material, UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements.
 - 2.4.2.5 Body and cover shall maintain physical properties through overall temperature range of -35°C to 110°C (-31°F to 230°F).
 - 2.4.2.6 Body shall be an industrial grey colour, and lid shall be either industrial grey or clear.
 - 2.4.2.7 Cover and body shall be free of rough corners, sharp edges, or burrs.
 - 2.4.2.8 Cover shall be mounted to body with integral hidden non-metallic hinges that shall provide 145° opening.
 - 2.4.2.9 Cover shall be removable and interchangeable.
 - 2.4.2.10 Body shall have integral boss for mounting quick release latches.
 - 2.4.2.11 Quick release (lockable) latches shall be available in either non-metallic, or in type 304 stainless steel.
 - 2.4.2.12 Cover screws (10-32) shall be captive with a slotted stainless steel (type 304) fillister head.
 - 2.4.2.13 Factory installed brass inserts shall be provided for cover (10-32), mounting flanges (1/4-20), and panel mounting (10-32) screws.
 - 2.4.2.14 Mounting flanges shall be removable and shall permit vertical or horizontal placement on the body.
 - 2.4.2.15 Back panel mounting means shall accept standard size back panels.
 - 2.4.2.16 Interior body corners shall have dovetail to permit panel to be mounted at any depth.
 - 2.4.2.17 Swing out panel mounts shall be utilized when a second panel is desired, or when access to the rear of the primary panel is desired.
 - 2.4.2.18 Hardware kit for adjustable panel mounting shall be available.
 - 2.4.2.19 Hardware kit for swing out panel mounting shall be available.
 - 2.4.2.20 Enclosure gasket shall be oil resistant continuous closed cell neoprene.
 - 2.4.2.21 Enclosure body shall have tapered edges to keep liquids away from cover opening.
 - 2.4.2.22 Back panel shall be available in either 14 gauge steel, painted white, or in 7 mm (1/4 in) PVC.
 - 2.4.2.23 Enclosure shall be available as factory assembly or as individual components.
 - 2.4.3 NEMA 12/4X external hinge cover enclosures:
 - 2.4.3.1 Enclosure shall be UL listed in accordance with UL 50 and CSA or cUL certified to CSA C22.2 No. 94.2.
 - 2.4.3.2 Enclosure shall have CSA enclosure ratings type 1, 2, 3, 3S, 3X, 3SX, 4, 4X, and 12.
 - 2.4.3.3 Body shall be manufactured from a high-impact, corrosion resistant solid engineering thermoplastic material, UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements.
 - 2.4.3.4 Cover shall be manufactured from either a high-impact, corrosion resistant solid engineering material, UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements, or a clear polycarbonate material, UV stabilized for outdoor use and comply with UL-94 minimum V-2 requirements.
 - 2.4.3.5 Body and cover shall maintain physical properties through overall temperature range of -35°C to 110°C (-31°F to 230°F).
 - 2.4.3.6 Body shall be an industrial grey colour, and lid shall be either industrial grey or clear.
 - 2.4.3.7 Cover and body shall be free of rough corners, sharp edges, or burrs.
 - 2.4.3.8 Cover shall be mounted to body with integral external non-metallic hinges that shall provide 240° opening.
 - 2.4.3.9 Cover shall be removable and interchangeable.
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- 2.4.3.10 Body shall have integral boss for mounting quick release latches.
- 2.4.3.11 Quick release (lockable) latches shall be available in either non-metallic, or in type 304 stainless steel.
- 2.4.3.12 Cover screws (10-32) shall be captive with a slotted stainless steel (type 304) fillister head.
- 2.4.3.13 Factory installed brass inserts shall be provided for cover (10-32), mounting flanges (1/4-20), and panel mounting (10-32) screws.
- 2.4.3.14 Mounting flanges shall be removable and shall permit vertical or horizontal placement on the body.
- 2.4.3.15 Back panel mounting means shall accept standard size back panels.
- 2.4.3.16 Interior body corners shall have dovetail to permit panel to be mounted at any depth.
- 2.4.3.17 Swing out panel mounts shall be utilized when a second panel is desired, or when access to the rear of the primary panel is desired.
- 2.4.3.18 Hardware kit for adjustable panel mounting shall be available.
- 2.4.3.19 Hardware kit for swing out panel mounting shall be available.
- 2.4.3.20 Enclosure gasket shall be oil resistant continuous closed cell neoprene.
- 2.4.3.21 Enclosure body shall have tapered edges to keep liquids away from cover opening.
- 2.4.3.22 Back panel shall be available in either 14 gauge steel, painted white, or in 7 mm (1/4 in) PVC.
- 2.4.3.23 Enclosure shall be available as factory assembly or as individual components.

2.5 SPLITTER TROUGHS

- 2.5.1 CSA approved.
- 2.5.2 NEMA 1, formed, factory primed and painted steel box enclosure with knockouts.
- 2.5.3 Hinged front cover plate.
- 2.5.4 Suitable mounting provisions.
- 2.5.5 Nameplate giving its rating.
- 2.5.6 Terminal blocks consist of pressure type main lugs and branch lugs approved for copper wiring and mounted on porcelain bases.
- 2.5.7 Splitter trough ratings are scheduled on the drawings.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install to CSA C22.1.
- 3.1.2 Install devices plumb and level.

3.2 CLEANING

- 3.2.1 Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Switches, receptacles, wiring devices, cover plates, and their installation.

1.2 UNIT PRICES

- 1.2.1 Submit with Tender unit prices to provide the following. Include installation in the unit price:
 - 1.2.1.1 5-15R specification grade duplex receptacle, complete with wiring and conduit, based on 10 metre distance from the local panelboard.
 - 1.2.1.2 5-20R specification grade duplex receptacle, complete with wiring and conduit, based on 10 metre distance from the local panelboard.
- 1.2.2 Unit cost of additional conduit and wire for the above items.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 14-13, Industrial control equipment.
 - 1.3.1.4 CSA C22.2 No. 42-10 (R2015), General use receptacles, attachment plugs, and similar devices.
 - 1.3.1.5 CSA C22.2 No. 42.1-13, Cover plates for flush-mounted wiring devices.
 - 1.3.1.6 CSA C22.2 No. 55-15 (R2020), Special use switches.
 - 1.3.1.7 CSA C22.2 No.111-10 (R2015), General-use snap switches.
 - 1.3.1.8 CSA C22.2 No. 182.1-17, Plugs, receptacles, and cable connectors of the pin and sleeve type.

1.4 INFORMATIONAL SUBMITTALS

- 1.4.1 Submit shop drawings and product data in accordance with Section 01 33 00.
- 1.4.2 Product Data: Provide manufacturer's catalogue information showing dimensions, colours, and configurations.
- 1.4.3 Submit manufacturer's installation instructions.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Eaton.
- 2.1.2 Hubbell Bryant.
- 2.1.3 Leviton.
- 2.1.4 Molex.
- 2.1.5 Pass & Seymour (Legrand).

2.2 WALL SWITCHES

- 2.2.1 Single pole, double pole, three-way, four-way switches to: CSA C22.2 No. 55 and CSA C22.2 No.111.
 - 2.2.2 Description: CSA 22.2 No. 111, Commercial Spec Grade, AC only general-use snap switch.
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- 2.2.3 Local switches shall be 20 A, silent, brown coloured, AC type and CSA certified, specification grade. Provide switches rated to suit system voltage 120 V or 347 V.
- 2.2.4 Manually-operated general purpose AC switches with following features:
 - 2.2.4.1 Terminal holes approved for 10 AWG wire.
 - 2.2.4.2 Silver alloy contacts.
 - 2.2.4.3 Urea or melamine moulding for parts subject to carbon tracking.
 - 2.2.4.4 Suitable for back and side wiring.
- 2.2.5 Voltage: 120 V or 347 V, AC as indicated.
- 2.2.6 Current: 20 A.
- 2.2.7 Body and Handle: white plastic with toggle handle. Confirm finish colour prior to ordering.
- 2.2.8 Toggle operated fully rated for tungsten filament and fluorescent lamps, and up to 80% of rated capacity of motor loads.
- 2.2.9 Example Products (Decorator style):
 - 2.2.9.1 120 V:
 - (1) Hubbell HBL2121 series.
 - 2.2.9.2 347 V:
 - (1) Pass & Seymour 2601-347 series.
- 2.2.10 Example Products (Toggle style):
 - 2.2.10.1 120 V:
 - (1) Hubbell HBL1221 (single pole).
 - (2) Hubbell HBL1222 (double pole).
 - (3) Hubbell HBL1223 (three-way).
 - (4) Hubbell HBL1224 (four-way).
 - 2.2.10.2 347 V:
 - (1) Hubbell HBL18221 (single pole).
 - (2) Hubbell HBL18223 (three-way).
 - (3) Pass & Seymour PS372030I.
- 2.2.11 Local switches and receptacles shall be of the same manufacturer throughout except where a specified item is not made by that manufacturer.

2.3 RECEPTACLES

- 2.3.1 General
 - 2.3.1.1 Description: CSA C22.2 No. 42, Commercial Spec Grade general use receptacles.
 - 2.3.1.2 Device Body: white plastic.
 - 2.3.1.3 Configuration: Type as specified and indicated.
 - 2.3.1.4 Convenience Receptacle: Type 5-15, 5-20 where indicated.
 - 2.3.1.5 GFCI Receptacle: Convenience receptacle with integral ground fault circuit interrupter to meet regulatory requirements.
 - 2.3.1.6 Data Room Receptacle Types: As indicated on drawings.
 - 2.3.1.7 Receptacles of one manufacturer throughout project.
- 2.3.2 Receptacles shall be white coloured, specification grade, unless noted otherwise.
- 2.3.3 Receptacles shall be as listed below:
 - 2.3.3.1 15 A, 120 V, single phase grounded duplex receptacle shall be NEMA-U-ground type CSA Configuration 5-15R.
 - 2.3.3.2 20 A, 120 V, single phase grounded duplex receptacle shall be NEMA-U-ground type CSA Configuration 5-20RA

- 2.3.3.3 15 A, 120 V, weatherproof receptacles shall be equal to those above but complete with gasketed cast plate and hinged covers.
- 2.3.4 Other types of receptacles shall be provided as shown on Drawings.
- 2.3.5 Duplex receptacles, CSA type 5-15 R, 125 V, 15 A, U ground, to: CSA C22.2 No. 42 with following features:
 - 2.3.5.1 White urea moulded housing.
 - 2.3.5.2 Suitable for No. 10 AWG for back and side wiring.
 - 2.3.5.3 Break-off links for use as split receptacles.
 - 2.3.5.4 Eight back wired entrances, four side wiring screws.
 - 2.3.5.5 Triple wipe contacts and riveted grounding contacts.
- 2.3.6 Single receptacles CSA type 5-15 R, 125 V, 15 A, U ground with following features:
 - 2.3.6.1 White urea moulded housing.
 - 2.3.6.2 Suitable for No. 10 AWG for back and side wiring.
 - 2.3.6.3 Four back wired entrances, 2 side wiring screws.
- 2.3.7 Other receptacles with ampacity and voltage as indicated.
- 2.3.8 Example Products (Decorator style duplex 5-15R):
 - 2.3.8.1 Pass & Seymour 26252 Series.
 - 2.3.8.2 Hubbell HBL2152 Series.
- 2.3.9 Ground Fault Circuit Interrupter (GFCI or GFI) Receptacles
 - 2.3.9.1 Protected by a ground fault circuit interrupter of the Class A type.
 - 2.3.9.2 Any receptacle within 1.5 m (5 ft) of a sink must be GFCI protected.
 - 2.3.9.3 Any receptacle located outdoor must be GFCI protected.
- 2.3.10 Isolated Ground (IG) Receptacles:
 - 2.3.10.1 Marked as such (green triangle).
 - 2.3.10.2 Example Products:
 - (1) Hubbell IG2152 (15 A duplex decorator style, orange faceplate).
- 2.3.11 Tamper-resistant receptacles.
 - 2.3.11.1 Marked as such (for example "TR").
 - 2.3.11.2 To be used in the following spaces:
 - (1) Child care facilities and kindergarten classrooms.
 - (2) Guest rooms and suites of hotels and motels.
 - (3) Preschools and elementary education facilities, including kindergarten facilities.
 - (4) Dwelling units.
 - 2.3.11.3 Example Products:
 - (1) Hubbell BR15WHITR (15 A duplex decorator style).
 - (2) Hubbell BR20WHITR (20 A duplex decorator style).
- 2.3.12 USB Charger receptacles: duplex tamper resistant device.
 - 2.3.12.1 USB ports: one type A and one type C USB charging port, 5 A, 5 V.
 - 2.3.12.2 Example: Hubbell USB15AC5WWR.

2.4 COVER PLATES

- 2.4.1 Cover plates for wiring devices to: CSA C22.2 No. 42.1.
 - 2.4.2 Cover plates from one manufacturer throughout project.
 - 2.4.3 Sheet steel utility box cover for wiring devices installed in surface-mounted utility boxes.
 - 2.4.4 Stainless steel, vertically brushed, cover plates, thickness 2.5 mm for wiring devices mounted in flush-mounted outlet box.
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- 2.4.5 Cast cover plates for wiring devices mounted in surface-mounted FS or FD type conduit boxes.
- 2.4.6 Weatherproof double lift spring-loaded cast aluminum cover plates, complete with gaskets for duplex receptacles as indicated.
- 2.4.7 Weatherproof spring-loaded cast aluminum cover plates complete with gaskets for single receptacles or switches.
- 2.4.8 Decorative Cover Plate: Polycarbonate.
 - 2.4.8.1 Pass & Seymour TP26W series.
- 2.4.9 Switch, receptacle, telephone, and other plates shall be stainless steel 18-8 chrome metal alloy, Type 302, non-metallic in finished areas and pressed steel in unfinished areas. Finish brush marks shall be run in a vertical direction.
- 2.4.10 Wet Location and weatherproof devices: receptacles and cover plates shall be suitable for wet locations and provide shielding with and without a plug inserted into the receptacle in accordance with 2021 OESC rule 26-708.
 - 2.4.10.1 Weatherproof Cover Plate: Ultra-rugged polycarbonate and synthetic neoprene rubber:
 - (1) Hubbell ML500GCN series (single-gang):
 - (A) low profile design which expands from 25 mm (1 in) to 75 mm (3 in) for weatherproof protection while an outlet is in use while maintaining the "Extra Duty" ratings.
 - (B) Clear window allows for quick/easy visual inspection.
 - (C) All required gasket and mounting hardware.
 - (D) Pre-configured for GFCI type receptacles.
 - (E) Complete with gaskets to accommodate duplex receptacles or Data outlets.
 - (F) NEMA 3R compliant.
 - (G) Colour: Gray.
 - (2) Hubbell ML2450GCN series (2-gang):
 - (A) low profile design which expands from 25 mm (1 in) to 75 mm (3 in) for weatherproof protection while an outlet is in use while maintaining the "Extra Duty" ratings.
 - (B) Clear window allows for quick/easy visual inspection.
 - (C) All required gasket and mounting hardware.
 - (D) Pre-configured for GFCI type receptacles.
 - (E) Complete with gaskets to accommodate quadplex receptacles or Data outlets.
 - (F) NEMA 3R compliant.
 - (G) Colour: Gray.

2.5 PENDANT RECEPTACLES

- 2.5.1 Pendant cord mounted single receptacles complete with strain relief device.
 - 2.5.2 Strain relief system: Hubbell Kellems Grips, Molex, or equal.
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2.6 RECEPTACLE CORD REELS

- 2.6.1 Retractable cable reel, mounted to structure above. 125 V, 5-20R c/w 40 feet of cable (or equal).
- 2.6.2 Provide framing bracket to support reel at underside of structure above.
- 2.6.3 Connect to GFCI breakers.
- 2.6.4 Manufacturers:
 - 2.6.4.1 Hubbell.
 - 2.6.4.2 Legrand.
 - 2.6.4.3 Woodhead (Molex).

2.7 SPECIAL WIRING DEVICES

- 2.7.1 Pilot lights as indicated, with neon type 0.04 W, 125 V lamp and red plastic jewel flush type.

2.8 PIN AND SLEEVE DEVICES

- 2.8.1 Manufacturers:
 - 2.8.1.1 Crouse-Hinds by Eaton.
 - 2.8.1.2 Hubbell.
 - 2.8.1.3 Meltric.
 - 2.8.1.4 Mennekes.
 - 2.8.1.5 Russellstoll (Thomas & Betts).
 - 2.8.1.6 Walther Electric.
- 2.8.2 Refer to equipment schedule and plans for locations and specific requirements.

2.9 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

- 2.9.1 In accordance with CSA C22.2 No. 159-18, Plugs, connectors, receptacles, and similar wiring devices for use in hazardous locations.
- 2.9.2 Manufacturers:
 - 2.9.2.1 Crouse-Hinds.
 - 2.9.2.2 Appleton Electric.
 - 2.9.2.3 Killark; Division of Hubbell Inc.

2.10 REGULATORY REQUIREMENTS

- 2.10.1 Provide products listed and classified by CSA (Canadian Standards Association).

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Verify that outlet boxes are installed at proper height.
- 3.1.2 Verify that wall openings are neatly cut and will be completely covered by wall plates.
- 3.1.3 Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 PREPARATION

- 3.2.1 Provide extension rings to bring outlet boxes flush with finished surface.
- 3.2.2 Clean debris from outlet boxes.

3.3 INSTALLATION

- 3.3.1 Install to CSA C22.1.
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- 3.3.2 Mounting heights in accordance with Section 26 05 00.
- 3.3.3 Install devices plumb and level.
- 3.3.4 Install switches with OFF position down.
- 3.3.5 Install wall dimmers to achieve full rating specified and indicated after de-rating for ganging as instructed by manufacturer.
- 3.3.6 Do not share neutral conductor on load side of dimmers.
- 3.3.7 Install receptacles with grounding pole on bottom.
- 3.3.8 Connect wiring device grounding terminal to outlet box with bonding jumper.
- 3.3.9 Install decorative plates on switch, receptacle, and blank outlets in finished areas.
- 3.3.10 Connect wiring devices by wrapping conductor around screw terminal.
- 3.3.11 Use jumbo size plates for outlets installed in masonry walls.
- 3.3.12 Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.
- 3.3.13 Switches:
 - 3.3.13.1 Install single throw switches with handle in "UP" position when switch closed.
 - 3.3.13.2 Install switches in gang type outlet box when more than one switch is required in one location.
- 3.3.14 Receptacles:
 - 3.3.14.1 Install receptacles in gang type outlet box when more than one receptacle is required in one location.
 - 3.3.14.2 Where split receptacle has one portion switched, mount vertically and switch upper portion.
 - 3.3.14.3 Connect receptacle grounding terminal to the outlet box with an insulated green ground strap.
 - 3.3.14.4 Receptacles for maintenance of HVAC and similar equipment located on rooftops.
 - (1) Provide weatherproof GFI 5-20R receptacles on roof, installed at 750 mm (30 in) above finished roof level, complete with wet location "while in use" "extra duty" cover plate.
 - (2) Locate within 7500 mm (25 ft) of new HVAC equipment, and at least 2000 mm (6.5 ft) away from roof line.
 - (3) Refer to 2021 OESC rules 2-316, 26-708, and 26-710, and OESC bulletin 26-27-0, or latest edition.
- 3.3.15 Cover plates:
 - 3.3.15.1 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.
 - 3.3.15.2 Install suitable common cover plates where wiring devices are grouped.
 - 3.3.15.3 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.
 - 3.3.15.4 Do not install plates until final painting of room or area is completed. Remove protective covering.
- 3.3.16 Circuit identification: in accordance with Section 26 05 53.

3.4 FIELD QUALITY CONTROL

- 3.4.1 Inspect each wiring device for defects.
 - 3.4.2 Operate each wall switch with circuit energized and verify proper operation.
 - 3.4.3 Verify that each receptacle device is energized.
 - 3.4.4 Test each receptacle device for proper polarity.
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3.4.5 Test each GFCI receptacle device for proper operation.

3.5 *ADJUSTING*

3.5.1 Adjust devices and wall plates to be flush and level.

3.6 *CLEANING*

3.6.1 Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

1 GENERAL

1.1 REFERENCES

- 1.1.1 CSA C22.2 No. 248 series.

1.2 SUBMITTALS

- 1.2.1 Provide submittals in accordance with Section 01 33 00.
- 1.2.2 Product Data:
 - 1.2.2.1 Provide fuse performance data characteristics for each fuse type and size above 200 amps. Performance data to include average melting time-current characteristics.
- 1.2.3 Shop Drawings:
 - 1.2.3.1 Provide shop drawings in accordance with Section 01 33 00.

1.3 DELIVERY, STORAGE, AND HANDLING

- 1.3.1 Ship fuses in original containers.
- 1.3.2 Do not ship fuses installed in switchboard.
- 1.3.3 Store fuses in original containers in storage cabinet.
- 1.3.4 Waste Management and Disposal:
 - 1.3.4.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 19.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- 1.4.1 Provide maintenance materials in accordance with Section 01 77 00.
- 1.4.2 3 spare fuses of each type and size installed above 600 A.
- 1.4.3 6 spare fuses of each type and size installed up to and including 600 A.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Bussman by Eaton.
- 2.1.2 GEC.
- 2.1.3 Littelfuse.
- 2.1.4 Mersen.
- 2.1.5 Substitutions: not permitted.

2.2 FUSES - GENERAL

- 2.2.1 Fuse type references L1, L2, J1, R1, etc. have been adopted for use in this specification.
- 2.2.2 Fuses: product of one manufacturer.
- 2.2.3 Fuses shall be sized as shown, time delay type, and of the same type throughout.
- 2.2.4 Fuses shall be CSA certified Class-J for 1-600 A or Class-L for 650 A and above.
- 2.2.5 Provide the following accessories where indicated or where required to complete installation:
 - 2.2.5.1 Fuseholders: Compatible with indicated fuses.
 - 2.2.5.2 Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for uses with larger ampere ratings.

2.3 FUSE TYPES

- 2.3.1 Class J fuses.
 - 2.3.1.1 Type J1, time delay, capable of carrying 500 per cent of its rated current for 10 seconds minimum.
 - 2.3.1.2 Type J2, fast acting.
- 2.3.2 Class L fuses.
 - 2.3.2.1 Type L1, time delay, capable of carrying 500 per cent of its rated current for 10 seconds minimum.
 - 2.3.2.2 Type L2, fast acting.
- 2.3.3 Class R fuses.
 - 2.3.3.1 Type R1, (UL Class RK1), time delay, capable of carrying 500 per cent of its rated current for 10 seconds minimum, to meet UL Class RK1 maximum let-through limits.
 - 2.3.3.2 Type R2, time delay, capable of carrying 500 per cent of its rated current for 10 seconds minimum.
 - 2.3.3.3 Type R3, (UL Class RK1), fast acting Class R, to meet UL Class RK1 maximum let-through limits.

2.4 FUSE REQUIREMENTS

- 2.4.1 Dimensions and Performance: CSA C22.2 No. 248 Series, Class as specified or indicated.
- 2.4.2 Voltage: Provide fuses with voltage rating suitable for circuit phase-to-phase voltage.
- 2.4.3 Power Load Feeder Switches: HRC-1 Class J time delay type.
- 2.4.4 Other Feeder Switches: HRC-1 Class J time delay type.

2.5 SPARE FUSE CABINET

- 2.5.1 Description: Wall-mounted sheet metal cabinet, suitably sized to store spare fuses and fuse pullers specified.
- 2.5.2 Doors: Hinged, with hasp for Owner's padlock.
- 2.5.3 Finish: Prime finish for field painting.
- 2.5.4 Dimensions: Minimum 914 mm by 914 mm by 305 mm (3 ft by 3 ft by 1 ft).

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install fuses to manufacturer's instructions.
- 3.1.2 Install fuse with label oriented such that manufacturer, type, and size are easily read.
- 3.1.3 Install spare fuse cabinet in electrical room.
- 3.1.4 Provide a complete set of fuses in each fusible device supplied under this Division and provide 3 spare fuses for each size used in spare fuse cabinet.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Molded-case circuit breakers.
- 1.1.2 Molded-case switches.
- 1.1.3 Accessories.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 24 13 – Switchboards.
- 1.2.2 Section 26 24 16 – Panelboards.

1.3 REFERENCES

- 1.3.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
- 1.3.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.3.3 CSA C22.2 No. 5-16, Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.
- 1.3.4 NEMA AB1 - Molded Case Circuit Breakers, Molded Case Switches, and Circuit - Breaker Enclosures.
- 1.3.5 NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment (published by the International Electrical Testing Association).

1.4 SUBMITTALS

- 1.4.1 Submit product data in accordance with Section 01 33 00.
- 1.4.2 Include time-current characteristic curves for breakers with ampacity of 400 A and above, or with interrupting capacity of 22,000 A symmetrical (rms) and over at system voltage.
- 1.4.3 Include termination temperature rating in degrees C.
- 1.4.4 Certificate of Origin
 - 1.4.4.1 Prior to any installation of circuit breakers in either a new or existing installation, Contractor must submit three (3) copies of a certificate of origin from the manufacturer, duly signed by the factory and the local manufacturer's representative, certifying that all circuit breakers come from this manufacturer, they are new and they meet standards and regulations. These certificates must be submitted to the Consultant for review.
 - 1.4.4.2 A delay in the production of the certificate of origin won't justify any extension of the contract and additional compensation.
 - 1.4.4.3 Any work of manufacturing, assembly or installation should begin only after acceptance of the certificate of origin by the Consultant. Unless complying with this requirement, Consultant reserves the right to mandate the manufacturer listed on circuit breakers to authenticate all new circuit breakers under the contract, and that, to Contractor's expense.
 - 1.4.4.4 In general, the certificate of origin must contain:
 - (1) The name and address of the manufacturer, and the person responsible for authentication. The responsible person must sign and date the certificate;
 - (2) The name and address of the licensed dealer, and the person of the distributor responsible for the Contractor's account.
 - (3) The name and address of the Contractor, and the person responsible for the project.

- (4) The name and address of the local manufacturer's representative. The local representative must sign and date the certificate.
- (5) The name and address of the building where circuit breakers will be installed:
 - (A) Project title.
 - (B) End user's reference number.
 - (C) The list of circuit breakers.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 Molded-case circuit breakers, Circuit breakers, and Ground-fault circuit-interrupters, Fused circuit breakers, and Accessory high-fault protectors: to CSA C22.2 No. 5.
- 2.1.2 Bolt-on Molded case circuit breaker: quick- make, quick-break type, for manual and automatic operation with temperature compensation for 40 degrees C ambient.
- 2.1.3 Plug-in Molded case circuit breakers: quick-make, quick-break type, for manual and automatic operation with temperature compensation for 40 degrees C ambient.
- 2.1.4 Common-trip breakers: with single handle for multi-pole applications.
- 2.1.5 Magnetic instantaneous trip elements in circuit breakers to operate only when value of current reaches setting.
 - 2.1.5.1 Trip settings on breakers with adjustable trips to range from 3-8 times current rating.
- 2.1.6 Circuit breakers with interchangeable trips.

2.2 INTERRUPTING CAPACITY

- 2.2.1 Protective devices shall be fully rated, for required available fault current. Series rated shall not be used on this installation.
- 2.2.2 Refer to Section 26 24 13, and Section 26 24 16.

2.3 MOLDED CASE CIRCUIT BREAKERS – GENERAL

- 2.3.1 Molded case circuit breaker to operate automatically by means of thermal and magnetic tripping devices to provide inverse time current tripping and instantaneous tripping for short circuit protection.
- 2.3.2 NEMA AB 1, circuit breakers with integral thermal and instantaneous magnetic trip in each pole.
- 2.3.3 Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits.
- 2.3.4 1-, 2-, or 3-pole bolt on, single-handle common trip voltage as indicated on drawings.
- 2.3.5 Overcentre toggle-type mechanism, quick-make, quick-break action. Trip indication is by handle position.
- 2.3.6 Calibrate for operation in 40 degree C ambient temperature.

2.4 MOLDED CASE CIRCUIT BREAKERS – UP TO 150 AMPERE

- 2.4.1 Permanent trip unit containing individual thermal and magnetic trip elements in each pole, unless noted otherwise on drawings.
-

2.5 MOLDED CASE CIRCUIT BREAKERS – 151 TO 224 AMPERE

- 2.5.1 Variable magnetic trip elements. Provide push-to-trip button on cover of breaker for mechanical tripping.

2.6 MOLDED CASE CIRCUIT BREAKERS –225 AMPERE AND ABOVE

- 2.6.1 Electronic trip type with adjustments for long-time, instantaneous, and short-time functions.
- 2.6.2 Provide ground fault function for breakers greater than 1000 Amps.
- 2.6.3 1000 Amp and Above:
 - 2.6.3.1 Modbus Communications
 - (1) Breaker status.
 - (A) Open.
 - (B) Closed.
 - (C) Tripped.
 - (2) Cause of trip.
 - (3) Time of trip.
 - (4) Current at time of trip.
 - (5) RMS currents per phase and ground.
 - (6) Peak demand.
 - (7) Present demand.
 - (8) Energy consumption.
- 2.6.4 1200 Amp and Above:
 - 2.6.4.1 Provide handle mechanisms that are lockable in the open (off) position.

2.7 ADDITIONAL FEATURES

- 2.7.1 Provide as indicated on drawings:
 - 2.7.1.1 Shunt trip.
 - 2.7.1.2 Auxiliary switch.
 - 2.7.1.3 Motor-operated mechanism.
 - 2.7.1.4 Under-voltage release.
 - 2.7.1.5 On-off locking device.
 - 2.7.1.6 Handle mechanism.

2.8 MOLDED-CASE SWITCHES

- 2.8.1 Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- 2.8.2 Accessories:
 - 2.8.2.1 Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
 - 2.8.2.2 Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.

2.9 ENCLOSED BREAKERS AND ENCLOSED MOLDED-CASE SWITCHES

- 2.9.1 Molded case, front operated, automatic circuit breakers sized as specified on drawings each secured in a NEMA 1, flush wall mounting enclosure with steel front panel.
-

- 2.9.2 Voltage rating suitable for circuit phase to phase voltage as indicated on drawings.
- 2.9.3 Units to include solid state adjustable trip units and contactors. Contactors to be of rating and type to suit application.

3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Install circuit breakers as per related sections.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Fusible and non-fusible enclosed low-voltage disconnect switches from 30 amps to 800 amps.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 28 13 – Fuses.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 4-16, Enclosed and Dead-Front Switches.
 - 1.3.1.4 CSA C22.2 No. 248 series, Low-voltage fuses.
- 1.3.2 NETA (International Electrical Testing Association) ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

1.4 SUBMITTALS

- 1.4.1 Product Data: Provide switch ratings, and enclosure dimensions.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Record actual locations of enclosed switches in project record documents.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Eaton Cutler-Hammer.
- 2.1.2 Siemens.
- 2.1.3 Square D by Schneider Electric.

2.2 REGULATORY REQUIREMENTS

- 2.2.1 Products: Listed and classified by CSA or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

2.3 DISCONNECT SWITCHES

- 2.3.1 Provide dedicated disconnect switches at electrical equipment.
 - 2.3.2 Fused or un-fused disconnect or safety switches: Type "A", quick-make, quick-break construction with provision for padlocking switches in either "ON" or "OFF" position.
 - 2.3.2.1 Quick-make, quick-break.
 - 2.3.2.2 Heavy duty industrial type.
 - 2.3.2.3 Lockable with up to 3 padlocks.
 - 2.3.2.4 Cover interlocked with switch mechanism.
 - 2.3.2.5 Viewing window for viewing blades.
 - 2.3.3 Fused switches equipped with fuse clips designed for Class "J" fuses and designed to reject standard NEC fuses.
 - 2.3.4 Enclosure: CSA Type 1 sprinkler-proof, or as noted.
 - 2.3.5 Switches throughout project of same manufacturer.
-

3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Provide fused or un-fused safety or disconnect switches as shown and as required by Code.
- 3.1.2 Install disconnect switches complete with fuses, if applicable, to CSA C22.1.
- 3.1.3 Apply neatly typed adhesive tag on inside door of each fusible switch indicating NEMA fuse class and size installed.
- 3.1.4 Coordinate fuse ampere rating with installed equipment. Fuse ampere rating variance between original design information and installed equipment, size in accordance with Bussmann Fusetron 40 degree C recommendations. Do not provide fuses of lower ampere rating than motor starter thermal units.

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Section Includes
 - 1.1.1.1 Roof mounted solar photovoltaic (PV) power generation systems.
 - 1.1.1.2 Common elements to roof mounted and Building-Integrated PV (BIPV) systems, including but limited to:
 - (1) Combiner boxes.
 - (2) Inverters.
 - 1.1.1.3 The Contractor shall provide the PV system, which includes:
 - (1) Design.
 - (2) Supply.
 - (3) Installation, including obtaining utility approvals for interconnection.
 - (4) Testing.
 - (5) Commissioning.
 - (6) Operation and Maintenance.
 - 1.1.1.4 The Contractor shall provide complete system documentation.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 07 44 63.02 – Building-Integrated PV Cladding Panels.
- 1.2.2 Section 26 24 13 – Switchboards.

1.3 PRICE AND PAYMENT PROCEDURES

- 1.3.1 The project is considering to have maximum available capacity, and minimum annual generation estimation of 67.5 MWh.
- 1.3.2 Submit:
 - 1.3.2.1 The annual performance evaluation report.
 - 1.3.2.2 The detailed financial analysis used to determine the ROI.
 - 1.3.2.3 The project plan, indicating the estimated timelines for installation, and required milestone dates from other trades.

1.4 DEFINITIONS

- 1.4.1 GFDI: Ground fault detection and interruption.
 - 1.4.2 LDC: local distribution company
 - 1.4.3 MPP: Maximum power point.
 - 1.4.4 MPPT: Maximum power point tracker.
 - 1.4.5 NOCT: Normal operating cell temperature.
 - 1.4.6 PCC: Point of Common Coupling, where the facility distribution system connects to the utility system.
 - 1.4.7 PV: Photovoltaic.
 - 1.4.8 SOP: Standing offer program.
 - 1.4.9 STC: Values of standard test conditions (100 mW/cm² irradiance, Air Mass 1.5 spectrum, 25°C).
-

1.5 REFERENCE STANDARDS

- 1.5.1 CSA Group:
 - 1.5.1.1 CSA C22.2 No. 107.1-16, Power conversion equipment (inverters).
 - 1.5.1.2 CSA C22.2 No. 182.5-14, Photovoltaic connectors.
 - 1.5.1.3 CSA C22.2 No. 248.19-15, Low-voltage fuses — Part 19: Photovoltaic fuses.
 - 1.5.1.4 CSA C22.2 No. 270-16, Arc-fault protective devices.
 - 1.5.1.5 CSA C22.2 No. 271-11 (R2016), Photovoltaic cables.
 - 1.5.1.6 CSA C22.2 No. 290-15, Photovoltaic combiners.
 - 1.5.1.7 CSA C22.2 No. 304-14, Enclosed and dead-front switches for photovoltaic applications.
 - 1.5.1.8 CSA C22.2 No. 305-16, Molded-case circuit breakers, molded-case switches, and circuit-breaker enclosures for use with PV systems.
 - 1.5.1.9 CSA C22.2 No. 330-17, Photovoltaic rapid shutdown systems.
 - 1.5.1.10 CAN/CSA-C22.2 No. 257-06 (R2011), Interconnecting inverter-based micro-distributed resources to distribution systems".
 - 1.5.1.11 CAN/CSA-C61215-08 (R2013), Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval (Adopted IEC 61215:2005, second edition, 2005-04).
 - 1.5.1.12 CAN/CSA-C22.2 No. 62109-1:16, Safety of power converters for use in photovoltaic power systems – Part 1: General requirements (Adopted IEC 62109-1:2010, first edition, 2010-04, with Canadian deviations).
 - 1.5.1.13 CAN/CSA-C22.2 No. 61730-1:11, Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction".
 - 1.5.1.14 CAN/CSA-C22.2 No. 61730-2:11, Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing".
- 1.5.2 International Electrical Commission (IEC):
 - 1.5.2.1 IEC 61215-1:2016 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements.
 - 1.5.2.2 IEC 61215-2:2016 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures.
- 1.5.3 Institute of Electrical and Electronics Engineers (IEEE):
 - 1.5.3.1 IEEE 1547-2003 - Standard for Interconnecting Distributed Resources with Electric Power Systems.
 - 1.5.3.2 IEEE 1547.1-2005 - Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.
- 1.5.4 Underwriters Laboratories, Inc. (UL):
 - 1.5.4.1 UL 790 – Standard Test Methods for Fire Tests of Roof Coverings.
 - 1.5.4.2 UL 1703 – Standard for Flat-Plate Photovoltaic Modules and Panels.
 - 1.5.4.3 UL 1741 – Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources.
- 1.5.5 Underwriters Laboratories of Canada (ULC):
 - 1.5.5.1 ULC/ORD-C1703-01 - Requirements for Flat-Plate Photovoltaic Modules and Panels.

1.6 ADMINISTRATIVE REQUIREMENTS

- 1.6.1 Coordination: Coordinate work of this Section with work of other trades for proper time and sequence to avoid construction delays.
 - 1.6.2 Pre-installation Meetings: Conduct pre-installation meeting two weeks prior to commencing work of this Section.
-

1.7 DELEGATED DESIGN SUBMITTALS

- 1.7.1 Electrical: Solar PV vendor to submit detailed plans of System to Electrical Safety Authority for ESA Plan Review. Include for costs for same.
- 1.7.2 Structural: For engineering of the panels, racking, and attachment to the roof structure, the manufacturer shall provide shop drawings signed and sealed by a structural engineer licensed in the jurisdiction of the project. The manufacturer's engineer should also do a general review of the installation and provide a letter to the Consultants, and Owner records.

1.8 ACTION SUBMITTALS

- 1.8.1 Submit listed submittals in accordance with Section 01 33 00.
- 1.8.2 Product Data - Submit specified products as follows:
 - 1.8.2.1 Manufacturer's product datasheet.
 - 1.8.2.2 Manufacturer's installation instructions.
 - 1.8.2.3 Catalog pages illustrating products to be incorporated into project.
- 1.8.3 Shop Drawings - Indicate information on shop drawings as follows:
 - 1.8.3.1 Scale plans showing layout and orientation of modules.
 - 1.8.3.2 Roof surfaces and slopes.
 - 1.8.3.3 Location of inverters, combiner boxes, disconnects and protective devices.
 - 1.8.3.4 Penetration plan.
 - 1.8.3.5 Mounting details.
 - 1.8.3.6 Electrical connection details, including schematic diagrams for dc and ac power systems.
 - 1.8.3.7 String, wiring, bonding, and grounding plan details.
 - 1.8.3.8 Labeling and signage details.
 - 1.8.3.9 Description of system operation and interconnection protection scheme.
 - 1.8.3.10 Roof installation ballast calculations to be submitted for structural engineer's review and approval.
- 1.8.4 System Performance Calculations - Provide updated energy output calculations based on the product data, system design and site conditions:
 - 1.8.4.1 Professional simulation programs:
 - (1) RETScreen.
 - (2) PVsyst.
 - (3) PV*sol.
 - 1.8.4.2 Calculations shall account for the following factors:
 - (1) Typical daily insolation/cloud cover/ambient temperatures.
 - (2) Module details: manufacturer's I-V curves, temperature coefficients, dimensions.
 - (3) Inverter details: part-load efficiency curves, MPPT tracking range.
 - (4) System design details: mounting angle, orientation, and tracking information (if included).
 - (5) Consistent factors for soiling, shading, etc.
 - 1.8.4.3 Calculations shall demonstrate that the expected energy output of the system as designed meets the minimum project requirements.

1.9 INFORMATION SUBMITTALS

- 1.9.1 Submit listed submittals in accordance with Section 01 33 00.
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- 1.9.2 Test and Evaluation Reports:
 - 1.9.2.1 Equipment documentation showing compliance with specified performance characteristics and physical properties.
- 1.9.3 Manufacturer's Instructions: Submit manufacturer's storage and installation instructions.

1.10 CLOSEOUT SUBMITTALS

- 1.10.1 Provide operation and maintenance data for photovoltaic systems for incorporation into manual specified in Section 01 77 00.
- 1.10.2 Include in Operation and Maintenance Manual instructions for the particular systems supplied and not general description of units manufactured by supplier and:
 - 1.10.2.1 Operation and maintenance instructions for PV system including start-up and shutdown, disconnection, grid interconnection, protection troubleshooting and reset procedures, module cleaning, module replacement and remote monitoring, to permit effective operation, maintenance, and repair.
 - 1.10.2.2 Technical data:
 - (1) Illustrated parts lists with parts catalogue numbers.
 - (2) Schematic diagram of electrical dc and ac power systems.
 - (3) Schematic diagram of electrical controls and communications interfaces.
 - (4) Certified copy of factory test results.
 - (5) Maintenance and replacement instructions and schedules.
 - (6) Precise details for adjustment and setting of protective relays or sensing controls which require on site adjustment.
 - 1.10.2.3 Warranty Documentation: Submit copy of warranty certificate, terms and conditions with the warranty start date noted.
- 1.10.3 Structural engineer's review of installation.

1.11 EXTRA STOCK MATERIALS

- 1.11.1 Provide maintenance materials in accordance with the manufacturer's recommendations.
- 1.11.2 Include, at a minimum:
 - 1.11.2.1 3 sets of each type of fuses.
 - 1.11.2.2 Special tools for servicing.

1.12 QUALITY ASSURANCE

- 1.12.1 Qualifications:
 - 1.12.1.1 Manufacturer:
 - (1) Having minimum 2 years experience manufacturing components similar to, or exceeding requirements of project.
 - (2) Having sufficient capacity to produce and deliver required materials without causing delay in work.
 - (3) Capable of providing field service representation during construction.
 - 1.12.1.2 Installer:
 - (1) Acceptable to the manufacturer, experienced in performing work of this section and has specialized in installation of work similar to that required for this project.
 - (2) Site foreman shall have a Construction Electrician (NOC 7241) Solar PV Systems Certified personnel certification.
-

1.13 WARRANTY

- 1.13.1 Warranty: Refer to Section 01 77 00 for general project warranty provisions.
- 1.13.2 PV Module Manufacturer's Warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and does not limit, other rights Owner may have under other Contract Documents.
 - 1.13.2.1 Warranty Term:
 - (1) Freedom from Defects in Materials and Workmanship: 10 years, commencing on date of substantial completion.
 - (2) 90 Percent of Minimum Power Output: 10 years, commencing on date of substantial completion.
 - (3) 80 Percent of Minimum Power Output: 25 years, commencing on date of substantial completion.
- 1.13.3 Component Warranties:
 - 1.13.3.1 Inverters / Power Conditioning Units:
 - (1) Freedom from Defects in Materials and Workmanship: 5 years, commencing on date of substantial completion.
- 1.13.4 Provide a minimum 1 year maintenance and service agreement (minimum two site visits) for each site included in contract. Provide additional service agreement options for the following:
 - 1.13.4.1 Extending maintenance and service agreement by 12 months.
 - 1.13.4.2 Extending maintenance and service agreement by 24 months.
 - 1.13.4.3 Extending maintenance and service agreement by 36 months.

2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- 2.1.1 Photovoltaic system consists of:
 - 2.1.1.1 PV modules.
 - 2.1.1.2 String Inverters.
 - 2.1.1.3 Power optimizers (if applicable).
 - 2.1.1.4 Protective devices.
 - 2.1.1.5 Combiner boxes and recombiner boxes (if applicable).
 - 2.1.1.6 Disconnecting means.
 - 2.1.1.7 Wiring, connectors, junction boxes and raceways.
 - 2.1.1.8 Grounding and bonding systems.
 - 2.1.1.9 Pre-manufactured Racking and mounting systems.
 - (1) Including pre-manufactured concrete ballast to fit into item 9 above.
 - 2.1.1.10 Equipment support structures and foundations.

2.2 GENERAL REQUIREMENTS

- 2.2.1 PV systems shall be monopolar, grounded configurations.
 - 2.2.2 Interactive systems complete with grid interconnections, without energy storage components.
 - 2.2.3 Arrays shall be mounted on roof. All installations shall be non-penetrating type on building roof.
 - 2.2.4 The panel capacity and inverter sizes, where shown on the drawings, are indicative only. The Contractor shall provide optimized panel configurations.
-

2.3 ROOF MOUNTED PHOTOVOLTAIC MODULES

- 2.3.1 All photovoltaic modules used for each site shall be of a single manufacturer and model, with identical specifications.
- 2.3.2 PV modules to be made in Canada.
- 2.3.3 Types permitted:
 - 2.3.3.1 Monocrystalline silicon. Single and Bi-facial.
- 2.3.4 Efficiency Reduction at 200 W per m²: Less than 5 percent reduction.
- 2.3.5 Tolerance: Minus 5 to plus 5 percent.
- 2.3.6 Maximum system voltage rating: 1000 Vdc.
- 2.3.7 Maximum Temperature Coefficient Magnitude of Pmax: 0.5% per °C (negative).
- 2.3.8 Ambient temperature rating: Minimum -20°C to 40°C.
- 2.3.9 Performance/design requirements:
 - 2.3.9.1 CAN/CSA-C61215 (Crystalline silicon PV - design qualification and type approval).
 - 2.3.9.2 CAN/CSA-C22.2 No. 61730-1 (PV module safety - requirements for construction).
 - 2.3.9.3 CAN/CSA-C22.2 No. 61730-2 (PV module safety - requirements for testing).
 - 2.3.9.4 CEC approved solar modules.
 - 2.3.9.5 FSEC Certified modules.
 - 2.3.9.6 Loading:
 - (1) Frames capable of withstanding loads of not less than 2400 Pa (50 psi) in a variety of mounting methods.
 - 2.3.9.7 Panel surface: Low glare material:
 - (1) Low-iron, high-transmission tempered glass.
 - (2) Anti-reflective coating or stippled glass/light trapping surface.

2.4 BUILDING INTEGRATED PHOTOVOLTAIC MODULES

- 2.4.1 In accordance with Section 07 44 63.02.

2.5 ENCLOSURES

- 2.5.1 All enclosures for outdoor installation shall be CSA/NEMA 3R or better.

2.6 COMBINER BOXES

- 2.6.1 Provide combiner boxes and recombiner boxes as needed to suit PV system layout and optimize the amount of wiring needed.
- 2.6.2 Identify each source and output circuit wire with permanent labels where they enter the box.
- 2.6.3 Surge protective devices to be installed within each combiner box and mounted so that lead length is minimized.
- 2.6.4 Voltage rating: matching dc system voltage.
- 2.6.5 Terminals: 90°C.
- 2.6.6 Where combiner boxes contain fuses, an integral external disconnect shall be provided and interlocked with the enclosure door as required by OESC rule 64-060.
- 2.6.7 Certification: to CSA C22.2 No. 290.

2.7 STRING OVERCURRENT PROTECTION

- 2.7.1 Install fuses or circuit breakers in each string sized to meet maximum series protection requirements of the connected PV modules, when it is required.
-

- 2.7.2 All fuses or circuit breakers protecting dc wiring shall be rated for use in dc photovoltaic applications at the maximum system voltage.
- 2.7.3 Arrays shall have overcurrent protection on all ungrounded conductors.
- 2.7.4 Overcurrent protection to be located within combiner boxes where provided. Alternately, overcurrent protection and string connections may be installed within the inverters.
- 2.7.5 Source circuit fuse holders shall be touch-safe design allowing disconnection of PV source circuits without fuse removal.

2.8 OVERCURRENT PROTECTION (GENERAL)

- 2.8.1 All overcurrent devices connected between multiple power sources shall be suitable to be backfed (i.e. do not have 'line' and 'load' markings and are not GFCI type).
- 2.8.2 Check existing breakers that are unsuitable to be backfed where the PV system is connected downstream of the 'load' side marking or a GFCI-type breaker.

2.9 DISCONNECTING MEANS

- 2.9.1 Provide disconnecting means at the following locations:
 - 2.9.1.1 AC system:
 - (1) Point of Common Coupling, where separate a utility service is used to connect the PV system. Disconnect shall be grouped with the facility load service disconnect.
 - (2) Inverter interactive system output.
 - 2.9.1.2 DC system:
 - (1) PV output circuits.
 - (2) Within 2 m of each combiner box or installed on the box cover.
 - (A) Combiner box disconnects shall be interlocked with the cover where the box contains fuses.
- 2.9.2 Disconnecting means shall be:
 - 2.9.2.1 Lockable in the open position.
 - 2.9.2.2 Capable of breaking full load current on all circuits.
 - 2.9.2.3 Capable of breaking 125% of the maximum PV short circuit current on PV output circuits.
 - 2.9.2.4 Rated for dc use at the maximum PV source voltage on dc circuits.
 - 2.9.2.5 Capable of disconnecting all ungrounded conductors of the circuit simultaneously, with all poles mechanically interlocked together.
 - 2.9.2.6 Externally operable without exposing the operator to live parts.
 - 2.9.2.7 Sufficient to safely de-energize inverters for removal and replacement.

2.10 INVERTERS

- 2.10.1 Certifications:
 - 2.10.1.1 CSA C22.2 No. 107.1.
 - 2.10.1.2 CAN/CSA-C22.2 No. 62109-1:16.
 - 2.10.2 Inverter types:
 - 2.10.2.1 String inverters.
 - 2.10.2.2 Approved alternate.
 - 2.10.3 DC Input:
 - 2.10.3.1 Voltage: selected to optimize system energy output.
 - 2.10.3.2 Grounded monopole.
 - 2.10.4 AC Output:
 - 2.10.4.1 Three-phase balanced, isolated, for three phase systems.
-

- 2.10.4.2 Voltage: to match site connection voltage, or use appropriate transformer.
- 2.10.5 Ambient temperature rating: Minimum -20°C to 60°C.
- 2.10.6 MPPT:
 - 2.10.6.1 Number of Channels: selected to optimize system energy output.
 - 2.10.6.2 Voltage range: selected to optimize system energy output.
- 2.10.7 Isolation transformer: integrated into inverter.
- 2.10.8 Ground fault detection and interruption (GFDI):
 - 2.10.8.1 Integral protection to detect and interrupt PV array dc ground faults.
 - (1) Daily pre-start protection to measure array conductor insulation resistance to ground.
 - (2) Continuous monitoring of ground return current and interruption of ungrounded conductors on ground faults. GFDI fuses in the dc grounding conductor not permitted.
 - (3) Inverter ac output shall be interrupted on dc ground faults.
 - 2.10.8.2 Provide ground fault trip functions on ac output circuit breakers where PV system connects to the utility service through ground fault trip devices.
- 2.10.9 Arc fault circuit interrupter (AFCI):
 - 2.10.9.1 Integral protection to detect and interrupt series and short arcing faults in PV array.
 - 2.10.9.2 Inverter ac output shall be interrupted on dc arc faults.
- 2.10.10 Efficiency: 97% minimum efficiency at standard test conditions.
- 2.10.11 Interconnection relaying:
 - 2.10.11.1 Anti-islanding protection.
 - 2.10.11.2 3-phase imbalance or loss of phase.
 - 2.10.11.3 Frequency and voltage limits.

2.11 RAPID SHUTDOWN FUNCTIONALITY

- 2.11.1 Inverter integrated, combiner integrated, stand-alone.
- 2.11.2 Initiation location.

2.12 GRID INTERCONNECTION

- 2.12.1 PV systems to be grid-interactive, and operating in parallel with the utility power supply.
- 2.12.2 Coordinate interconnection requirements with the power utility, including:
 - 2.12.2.1 Implementing utility interconnection requirements.
 - 2.12.2.2 Design documentation submittals.
 - 2.12.2.3 Relaying configuration and settings.
 - 2.12.2.4 Revenue metering modifications or installation.
 - 2.12.2.5 Commissioning documentation submittals, including declaration of compatibility.
 - 2.12.2.6 Facilitating utility witness testing and site acceptance verification as required.
 - 2.12.2.7 Pay all incremental utility costs associated with interconnection studies and reviews.
 - 2.12.2.8 Obtaining approval from LDC for ongoing parallel operation of the PV systems with the utility supply.
- 2.12.3 In compliance with the LDC interconnection requirements.

2.13 MOUNTING AND STRUCTURE

- 2.13.1 Pre-manufactured system, complete with wind deflectors.
 - 2.13.2 Pre-manufactured concrete ballast designed for racking system.
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- 2.13.3 Max system static load including ballast is 10 lbs/sq.ft. unless otherwise noted on drawings.

- 2.13.3.1 Ballast calculations to be submitted for structural engineer's review.

2.14 SYSTEM FIRE PERFORMANCE

- 2.14.1 Roof mount PV modules fire performance class to meet or exceed roof class "Class A" and of a type compatible for the mounting system to achieve meet or exceed the same class.

2.15 METERING AND MONITORING

- 2.15.1 Revenue metering:
 - 2.15.1.1 Net Metering: coordinate and pay for replacement of existing utility revenue meter as needed to permit bidirectional power flow measurement.
- 2.15.2 Inverter-level monitoring:
 - 2.15.2.1 The monitoring system shall have no monthly cost and will be part of the initial installation cost, which includes the lifetime storage and access of data.
 - 2.15.2.2 The monitoring system shall be web based and the default dashboard display will be determined with the client representative and client.

2.16 SURGE PROTECTIVE DEVICES (SPD)

- 2.16.1 Certification: CSA C22.2 No. 269.2-17.
- 2.16.2 Type 2 SPDs.
- 2.16.3 Voltage rating: to match circuit maximum voltage rating.
- 2.16.4 Short Circuit Current Rating: to match available fault current on circuit.
- 2.16.5 DC Circuits:
 - 2.16.5.1 Surge Capacity: minimum 40 kA per mode/phase.
- 2.16.6 AC Circuits:
 - 2.16.6.1 Surge Capacity: minimum 80 kA per phase.
- 2.16.7 Indication:
 - 2.16.7.1 Visual failure indication on modules
- 2.16.8 Install with leads as short as possible, 300 mm maximum. Integrate SPD into equipment enclosures where possible.

2.17 DC WIRING AND RACEWAYS

- 2.17.1 Wiring:
 - 2.17.1.1 RPVU90 conductors to CSA C22.2 No. 271.
 - 2.17.1.2 RPVU90 wiring permitted from modules to combiner boxes, where supported in raceway and wiring channels sufficient to prevent public access or rodent damage.
- 2.17.2 Wiring colour:
 - 2.17.2.1 Red or black with permanent '+' markings in white for positive conductors.
 - 2.17.2.2 Black (solid) or black with permanent '-' markings in white for negative conductors.
 - 2.17.2.3 Insulation voltage: 1000 V.
- 2.17.3 Wiring Methods and Raceways:
 - 2.17.3.1 For outdoor applications where the PV arrays are connected together, or the distance of feeder is less than 1 m, install cable in 41 mm (1-1/2") PVC conduit. For lengths greater than 1 m, use rigid metal conduit (RMC).
 - 2.17.3.2 All PV system within buildings shall be installed in EMT conduit.

- 2.17.3.3 Provide expansion joints in all exterior conduit runs as needed to prevent damage from thermal expansion and contraction throughout the full ambient temperature range.
- 2.17.3.4 Open wiring on rear of modules to be installed within protective wiring channels.
- 2.17.3.5 Installations in open cable tray and direct burial are not permitted.
- 2.17.3.6 Cable in enclosed cable tray on roof is permitted.
- 2.17.3.7 Connections to vibrating equipment shall use liquid-tight flexible metallic conduit.
- 2.17.3.8 Module interconnections may use open wiring methods and compatible fittings supplied as part of an approved module assembly.
- 2.17.3.9 Rigid metal conduit shall be used where installations are subject to mechanical damage.
- 2.17.3.10 Other methods permitted where indicated.
- 2.17.3.11 Connections to boxes and enclosures shall use bushings or cable glands compatible with the wiring type and box NEMA/CSA rating. All outdoor connections shall be watertight.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install as indicated on drawings.
- 3.1.2 Complete wiring and interconnections as indicated on drawings.
- 3.1.3 Complete and document commissioning for all systems, correct any deficiencies.
- 3.1.4 Facilitate utility witness testing and obtain final utility sign-off of system interconnection.

3.2 LABELLING

- 3.2.1 System diagram: at inverter, point of common coupling, etc.
- 3.2.2 High voltage warning:
 - 3.2.2.1 On circuits above 750V dc (OESC rule 64-202(5)).
- 3.2.3 Switches:
 - 3.2.3.1 "May be energized while open" (OESC rule 14-414, 64-112(4)(b)(i)).
 - 3.2.3.2 "Do not relocate breaker" in panels where breaker must be at the far end from the utility supply (OESC rule 64-112(4)(b)(iii))
- 3.2.4 Boxes w/ multiple source/output circuits: (OESC rule 64-210(10)(b)).
 - 3.2.4.1 Warning that multiple circuits are available.
- 3.2.5 At PV output circuit (dc) disconnect: 9.5 mm minimum lettering height, white text on red background (OESC rule 64-200).
 - 3.2.5.1 System rated V/I, max source circuit voltage, short circuit current.
 - 3.2.5.2 Indication if the system is equipped with rapid shutdown.

3.3 FIELD QUALITY CONTROL

- 3.3.1 Notify the Consultant 10 working days in advance of test date.
- 3.3.2 Demonstrate:
 - 3.3.2.1 System start, connection to load, unit shut down, and on automatic control.
 - 3.3.2.2 System disconnection on loss of mains power
 - 3.3.2.3 Operation of disconnect switches.
 - 3.3.2.4 Operation of automatic alarms and protective devices.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Factory assembled packaged gas-engine generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator.
- 1.1.2 Exhaust silencer and fittings.
- 1.1.3 Fuel fittings.
- 1.1.4 Remote control panel.
- 1.1.5 Battery and charger.
- 1.1.6 Weatherproof skin-tight enclosure.
- 1.1.7 Accessories.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 03 30 00 – Cast-in-Place Concrete.
- 1.2.2 Section 23 11 23 – Facility Natural-Gas Piping.
- 1.2.3 Section 26 08 32.16 – Performance Checklist for Natural-Gas Generators.
- 1.2.4 Section 26 36 23.13 – Bypass-Isolation Automatic Transfer Switches.
- 1.2.5 Section 26 52 13.13 – Emergency Lighting.
- 1.2.6 Section 28 46 13 – Fire-Alarm Systems.

1.3 ALTERNATIVES

- 1.3.1 The generator set manufacturer shall supply an itemized listing of optional prices to provide additional service and maintenance as per semi-annual (Table 4) and annual inspections (Table 5) identified in CSA C282 and show as an alternative price with the quotation.

1.4 REFERENCES

- 1.4.1 CSA Group:
 - 1.4.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.4.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.4.1.3 CSA C22.2 No. 5-16 – Molded-Case Circuit Breakers: Molded case switches and circuit breaker enclosures (Tri-National standard, with UL 489 and NMX-J-266-ANCE).
 - 1.4.1.4 CSA C22.2 No. 100-14 – Motors and Generators.
 - 1.4.1.5 CSA C22.2 No. 141-15 (R2020) – Emergency Lighting Equipment.
 - 1.4.1.6 CSA C282:19 – Emergency Electrical Power Supply for Buildings.
 - 1.4.1.7 CSA B149.1:20 – Natural Gas and Propane Code.
 - 1.4.1.8 CSA Z245.1-18, Steel pipe.
- 1.4.2 Ontario Fire Code, latest edition.
- 1.4.3 O.Reg. 524/98, Environmental Compliance Approvals – Exemptions for Section 9 of the Act.
- 1.4.4 National Fire Code of Canada 2010.
- 1.4.5 Technical Standards & Safety Authority (TSSA) of Ontario:
 - 1.4.5.1 FS-255-21 – Gaseous Fuels Code Adoption Document Amendment: Ontario amendments to CSA B149:20 series.
- 1.4.6 Underwriters' Laboratories of Canada:

- 1.4.6.1 CAN/ULC-S524-14 – Standard for Installation of Fire Alarm Systems.
- 1.4.6.2 CAN/ULC-S1001-11, Integrated Systems Testing of Fire Protection and Life Safety Systems.

1.5 SUBMITTALS

- 1.5.1 To Section 01 33 00.
 - 1.5.2 Work of this Section is to be submitted for review after Consultant's review of Coordination Study per Section 26 05 73.16 is completed.
 - 1.5.3 The generator set vendor is to provide a detailed load summary report to verify that the frequency and voltage transient performance is in compliance with CSA C282.
 - 1.5.4 Shop Drawings:
 - 1.5.4.1 Indicate electrical characteristics and connection requirements. Show plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, ventilation and combustion air requirements, and electrical diagrams, including schematic and interconnection diagrams.
 - 1.5.4.2 Outline drawings of assembly, including sound attenuated weatherproof enclosure and accessories.
 - 1.5.4.3 Weight of complete assembly, including fuel.
 - 1.5.4.4 One line diagrams and wiring diagrams for assembly and components.
 - 1.5.4.5 Interconnection wiring diagrams.
 - 1.5.4.6 Sealed structural engineer's drawings for concrete foundation that are coordinated with the actual equipment dimensions, weights, and conduit stub-up location.
 - 1.5.5 Product data:
 - 1.5.5.1 Provide data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, and remote radiator.
 - 1.5.5.2 Technical data on all major components. Technical data must include an alternator thermal damage curve, description and operating characteristics of the alternator protection device, and an alternator reactive capability curve. Alternator data demonstrating compliance to section.
 - 1.5.5.3 Certification of the emissions performance of the generator set engine by the engine manufacturer.
 - 1.5.5.4 Seismic certification, as required.
 - 1.5.5.5 Acoustical information of enclosure.
 - 1.5.6 Line-by-line compliance statement that demonstrates compliance with this Section.
 - 1.5.7 Test Reports: Indicate results of performance testing.
 - 1.5.8 Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
 - 1.5.9 Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
 - 1.5.10 Manufacturer's Field Reports: Indicate procedures and findings.
 - 1.5.11 Data for Ministry of Environment Environmental Activity and Sector Registry (Certificate of Approval).
 - 1.5.11.1 The maximum electrical output rating of the generator set (kW).
 - 1.5.11.2 Manufacturer's combustion contaminant emissions data or U.S. EPA emissions standard certification sheet.
 - 1.5.11.3 Layout drawing showing engine exhaust stack orientation, for generator sets installed in outdoor enclosures.
 - 1.5.11.4 Enclosure layout drawing.
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- 1.5.11.5 Manufacturer's enclosure noise emissions data.
- 1.5.12 Colour samples for custom enclosure colour.
- 1.5.13 Project information:
 - 1.5.13.1 Test reports and certifications.
 - 1.5.13.2 Factory test procedures.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 Startup reports:
 - 1.6.1.1 Manufacturer's startup reports.
 - 1.6.1.2 Section 26 08 32.16 – Performance Checklist for Natural-Gas Generators.
- 1.6.2 AHJ inspection documentation:
 - 1.6.2.1 Fuelling compliance certificate.
 - 1.6.2.2 Variance approval correspondence, as applicable.
- 1.6.3 Maintenance Contracts:
 - 1.6.3.1 Manufacturer to maintain model and serial number records of each generator set provided for at least 20 years.
 - 1.6.3.2 The manufacturer shall itemize the complete offering of preventative and full-service maintenance contracts for the generator with submission, as described for each maintenance period described below.
 - 1.6.3.3 Maintenance service as part of base bid submission:
 - (1) Provide 7 x 24 x 365 service and maintenance of Generator for 2 years from Date of Substantial Completion. Price is to include two (2) full service maintenance program visits per each year.
 - 1.6.3.4 Additional maintenance service offers:
 - (1) Provide a separate price to extend 7 x 24 x 365 service and maintenance of generator for year three to year five.
- 1.6.4 Operation and Maintenance Data:
 - 1.6.4.1 Operation Data: Include instructions for normal operation.
 - 1.6.4.2 Maintenance Data: Include instructions for routine maintenance requirements, service manuals for engine, oil sampling and analysis for engine wear, and emergency maintenance procedures.
 - 1.6.4.3 Provide electronic copies of all documents, test data, shop drawings, etc.
- 1.6.5 Training records including attendance sheet, date, and training syllabus.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- 1.7.1 Provide three copies of maintenance materials.
 - 1.7.2 Spare Parts:
 - 1.7.2.1 Provide two of each of the following:
 - (1) Fuel oil filter element.
 - (2) Lube oil filter element.
 - (3) Air filter element.
 - (4) Fuel water separator.
 - 1.7.3 Tools: provide one set of tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal tool box.
 - 1.7.4 Keys.
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1.8 MANUFACTURER'S QUALIFICATIONS

- 1.8.1 The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.
- 1.8.2 The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
- 1.8.3 The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.
- 1.8.4 The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
- 1.8.5 The manufacturer of this equipment shall have produced similar equipment for a minimum period of ten years. When requested by the Consultant, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- 1.8.6 Manufacturer: Company specializing in manufacturing the products specified in this section with minimum 2 years documented experience, and with service facilities within 160 km of project.
- 1.8.7 Supplier: Authorized or franchised distributor of specified manufacturer with minimum 3 years documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

- 1.9.1 Store equipment in original, undamaged package.
- 1.9.2 Deliver to the project site in manufacturer's original wrapping and containers, labelled with manufacturer's name, product information, etc.
- 1.9.3 Coordinate delivery date and time with the Owner and equipment supplier.
- 1.9.4 Installing contractor to accept unit on site, inspect for damage, provide craning complete with spreader bars, and install equipment.

1.10 WARRANTY

- 1.10.1 Warrant the material and workmanship of the generator set and associated equipment for a minimum of 2 years from registered commissioning and start-up, or 30 months from date of arrival on site.
- 1.10.2 The manufacturer of the generator set(s) shall offer an extended coverage for years two to five. Provide and show separate in quote.
- 1.10.3 The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.
- 1.10.4 Warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Service of the generators sets to be performed by technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Manufacturer List:
 - 2.1.1.1 Cummins Power Generation, model C350N6 (Basis of Design).

- 2.1.1.2 Caterpillar.
- 2.1.1.3 Generac Power Systems by Total Power Ltd.
- 2.1.1.4 Kohler Power Systems.
- 2.1.1.5 Paramount Power Systems/MTU.
- 2.1.2 Substitution Limitations: Only those manufacturers listed above shall supply equipment provided under this contract. Proposals must include a line-by-line compliance statement based on this specification.

2.2 REGULATORY REQUIREMENTS

- 2.2.1 Generator set to be listed and labelled by a certification organization accredited by the Standards Council of Canada.
- 2.2.2 Comply with all applicable EPA emissions standards at the date of installation.
- 2.2.3 Conform to requirements of CSA C22.1, the Ontario Electrical Safety Code, and other requirements of the Electrical Safety Authority (ESA).
- 2.2.4 Conform to all requirements of CSA C282.
- 2.2.5 Provide products listed and classified by CSA (Canadian Standards Association) as suitable for purpose specified and indicated.
- 2.2.6 Installation in accordance with the National Fire Code of Canada.

2.3 GENERATOR SET

- 2.3.1 Ratings
 - 2.3.1.1 The generator set shall operate at 1800 rpm and at a voltage of: 347/600 volts AC, three phase, 4-wire, 60 Hz.
 - 2.3.1.2 The generator set shall be rated per ISO 8528 at 350 kW at 0.8 PF, standby rating, based on site conditions of:
 - (1) Altitude: 914 m (3000 ft).
 - (2) Ambient temperatures up to 40°C (104°F)
 - 2.3.1.3 Emissions:
 - (1) 25 kW to 300 kW – EPA Tier 3 certified.
 - (2) 350 kW to 2250 kW – EPA Tier 3 certified.
 - 2.3.1.4 Standby rating, based on site conditions of: Altitude 400 m above sea level, ambient temperatures of 40°C, based on temperature measured at the control for indoor installations, and measured at the air inlet closest to the alternator for outdoor equipment.
- 2.3.2 Performance
 - 2.3.2.1 Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load for both parallel and non-parallel applications. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
 - 2.3.2.2 Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.25%.
 - 2.3.2.3 The engine-generator set shall be capable of single step load pick up of 100% nameplate kW and power factor, less applicable derating factors, with the engine generator set at operating temperature.
 - 2.3.2.4 Motor starting capability shall be a minimum of 1749 kVA. The generator set shall be capable of sustaining a minimum of 90% of rated no load voltage with the specified kVA load at near zero power factor applied to the generator set.
 - 2.3.2.5 The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to

- neutral, and with not more than 3% in any single harmonic. Telephone influence factor shall be less than 40.
- 2.3.2.6 The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.
 - 2.3.2.7 The time required to automatically start, accelerate to rated speed and voltage, synchronize to the system bus on a normal power failure shall not exceed 15 seconds, assuming that the generator sets are in an ambient temperature of 15 degrees C or greater, and water jacket heaters are operating properly.
 - 2.3.2.8 The generator set, complete with sound attenuated enclosure, shall be tested by the generator set manufacturer per ANSI S1.13. Data documenting performance shall be provided with submittal documentation.
- 2.3.3 Construction
- 2.3.3.1 The engine generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
 - 2.3.3.2 All switches, lamps, and meters in the control system shall be oil tight and dust tight, and the enclosure door shall be gasketed. There shall be no exposed points in the control (with the door open) that operate in excess of 50 V.
- 2.3.4 Connections
- 2.3.4.1 The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as described in this specification. Sufficient lug space shall be provided for use with cables.
 - 2.3.4.2 Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
 - 2.3.4.3 Generator set control interfaces to other system components shall be made on a common, permanently labeled terminal block assembly.

2.4 ENGINE AND ENGINE EQUIPMENT

- 2.4.1 The engine shall be natural gas fueled, radiator and fan cooled. Minimum displacement shall be 0.52 litres (32 cubic inches), with 6 cylinders. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Engine accessories and features shall include:
- 2.4.1.1 Complete engine fuel system, including all pressure regulators, strainers, and control valves. The fuel system shall be plumbed to the generator set skid for ease of site connections to the generator set.
 - 2.4.1.2 An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous or parallel states.
 - 2.4.1.3 Skid mounted radiator and cooling system rated for full load operation in 40°C (104°F) ambient as measured at the generator air inlet, based on 0.5 in H₂O external static head. Radiator shall be sized based on a core temperature that is 20°F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene

- glycol/water mixture. Rotating parts shall be guarded against accidental contact.
- 2.4.1.4 Electric starter(s) capable of three complete cranking cycles without overheating.
 - 2.4.1.5 Positive displacement, mechanical, full pressure, lubrication oil pump.
 - 2.4.1.6 Full flow lubrication oil filters with replaceable spin on canister elements and dipstick oil level indicator.
 - 2.4.1.7 Replaceable dry element air cleaner with restriction indicator.
 - 2.4.1.8 Flexible fuel lines.
 - 2.4.1.9 Engine mounted battery charging alternator, 40 A minimum, and solid-state voltage regulator.
- 2.4.2 Coolant Heater
- 2.4.2.1 Engine mounted, thermostatically controlled, coolant heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
 - 2.4.2.2 The coolant heater shall be installed on the engine with SAEJ20 compliant materials. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 300 mm (12 in). The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall be installed using isolation valves to isolate the heater for replacement of the heater element. The design shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
 - 2.4.2.3 The coolant heater shall be provided with a 24 VDC thermostat, installed at the engine thermostat housing. An AC power connection shall be provided for a single AC power connection to the coolant heater system.
 - 2.4.2.4 Coolant heater(s) sized as recommended by the engine manufacturer to warm the engine to a minimum of 40°C in a 15°C ambient, in compliance with CSA C282 requirements, as a minimum, or the temperature required for starting and load pickup requirements of this section.
- 2.4.3 Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
- 2.4.4 Starting and Control Batteries: lead acid type, 24 VDC, sized as recommended by the engine manufacturer for compliance to CSA C282 starting requirements, complete with battery cables and connectors.
- 2.4.5 Exhaust Silencer:
- 2.4.5.1 Provide exhaust silencer for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer.
 - 2.4.5.2 The silencer shall be selected by the manufacturer to suit the overall noise rating of the enclosed unit in Part 2 Article "Weatherproof Skin-Tight Enclosure".
 - 2.4.5.3 Exhaust system shall be installed according to the engine manufacturer's recommendations and applicable codes and standards.
 - 2.4.5.4 Complete exhaust system to be installed within the enclosure, with vertical exhaust discharge.
 - (1) Vertical exhaust discharge extends a minimum of 1.2 m (4 ft) above the roof of the enclosure to ensure the following:
 - (A) Hot air does not recirculate in the air intake and overheat the engine.
 - (B) In case any snow builds up on the enclosure roof, the exhaust discharge is not covered which could prevent operation of the unit.
 - (2) Vertical exhaust discharge be complete with rain cap.
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- 2.4.5.5 Includes provisions for draining moisture that condenses in the exhaust system that could lead to corrosion.
- 2.4.5.6 Provide Stainless Steel exhaust flex connector to suit engine outlet connection, minimum 610 mm (24") length.
- 2.4.6 Provide a minimum 10 A battery charger for each generator set battery bank. The charger shall include the following capabilities:
 - 2.4.6.1 Chargers shall be UL 1236-BBHH listed and CSA or CUL certified for use in emergency applications.
 - 2.4.6.2 The charger shall be compliant with UL 991 requirements for vibration resistance.
 - 2.4.6.3 The charger shall comply with the requirements of EN61000-4-5 for voltage surge resistance; EN50082-2 for immunity; EN61000-4-2 for ESD; N61000-4-3 for radiated immunity; ANSI/IEEE C62.41 category B and IN61000-4-4 for electrically fast transient; EN61000-4-6 for conducted emissions; and FCC Part 15 Class A for radiated emissions.
 - 2.4.6.4 The charger shall be capable of charging a fully discharged battery without damage to the charger. It shall be capable of returning a fully discharged battery to fully charged condition within 24 hours. The charger shall be UL-labeled with the maximum battery amp-hour rating that can be recharged within 24 hours.
 - 2.4.6.5 The charger shall incorporate a 4-state charging algorithm, to provide trickle charge rate to restore fully discharged batteries, a bulk charge rate to provide fastest possible recharge after normal discharge, an absorption state to return the battery to 100 percent of charge, and a float stage to maintain a fully charge battery and supply battery loads when the generator set is not operating. In addition, the charger shall include an equalization timer. Charge rates shall be temperature compensated based on the temperature directly sensed at the battery.
 - 2.4.6.6 The DC output voltage regulation shall be within plus or minus 1%. The DC output ripple current shall not exceed 1 A at rated output current level.
 - 2.4.6.7 The charger shall include the following features:
 - (1) Two line alphanumeric display with programming keys to allow display of DC output ammeter and voltmeters (5% accuracy or better), display alarm messages, and perform programming;
 - (2) LED indicating lamp(s) to indicating normal charging condition (green), equalize charge state (amber), and fault condition (red);
 - (3) AC input overcurrent, over voltage, and undervoltage protection;
 - (4) DC output overcurrent protection;
 - (5) Alarm output relay;
 - (6) Corrosion resistant aluminum enclosure
- 2.4.7 Emissions Requirements
 - 2.4.7.1 NOx not to exceed 9.2 g NOx per kWh.
 - 2.4.7.2 Engine exhaust to be complete with catalytic converter for units over 80 kW.

2.5 AC ALTERNATOR

- 2.5.1 The AC alternator shall be; synchronous, four pole, 2/3 pitch, brushless, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. The alternator design shall prevent shaft current from flowing and eliminate the need for insulated bearings. All insulation system components shall meet NEMA MG1

requirements for Class H insulation systems. Actual temperature rise measured by resistance method at full load shall not exceed 105°C in a 40°C ambient.

- 2.5.2 The alternator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage up to 15 percent above or below rated voltage.
- 2.5.3 A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.
- 2.5.4 The alternator shall be supplied with a dedicated, independent power source for the voltage regulation system, which provides sufficient excitation for the alternator to supply 300 per cent of rated output current for 10 seconds.
- 2.5.5 The subtransient reactance of the alternator to not exceed 15 per cent, based on the standby rating of the generator set.
- 2.5.6 Provide an anti-condensation heater for the alternator for generator sets installed outdoors or in unheated environments.
- 2.5.7 Provide two embedded resistance temperature detectors per phase and temperature indication equipment. The control system shall annunciate high alternator temperature as a fault condition.
- 2.5.8 The alternator shall be capable of operation with reverse kVAR of 0.15 per unit.

2.6 GENERATOR SET CONTROL

- 2.6.1 The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, protection, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.
- 2.6.2 The control shall be mounted on the generator set in an accessible location. The control shall be vibration isolated, and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.
- 2.6.3 The generator set mounted control shall include the following features and functions:
 - 2.6.3.1 Control Switches
 - (1) Mode Select Switch.
 - (A) The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 - (2) EMERGENCY STOP switch.
 - (A) Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting. The switch shall include a lockout provision for use in safely disabling the generator set for necessary service.
 - (B) Locate inside Generator enclosure.
 - (3) RESET switch.

- (A) The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 - (4) PANEL LAMP switch.
 - (A) Operating the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is operated, or after the switch is operated a second time.
 - (5) Voltage and Frequency Adjustment. The genset mounted control shall include digital raise/lower switches for adjustment of voltage and frequency.
- 2.6.3.2 Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:
- (1) Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output kW, kWh, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three-phase voltages (line to neutral or line to line) simultaneously.
 - (2) Analog voltmeter, ammeter, frequency meter, power factor meter, and kilowatt (kW) meter. Voltmeter and ammeter shall display all three phases. Meter scales shall be colour coded in the following fashion: green shall indicate normal operating condition, amber shall indicate operation in ranges that indicate potential failure, and red shall indicate failure impending. Metering accuracy shall be within 1% at rated output. Both analog and digital metering are required.
 - (3) The control system shall monitor the total load on the generator set, and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10% increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.
 - (4) The control system shall log total number of operating hours, total kWh, and total control on hours, as well as total values since reset.
- 2.6.3.3 Generator Set Alarm and Status Display.
- (1) The generator set control shall include LED alarm and status indication lamps. The lamps shall be high intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:
 - (2) The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for any status, warning, or shutdown function monitored by the genset. They shall also be configurable for colour, and control action (status, warning, or shutdown).
 - (3) The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.
 - (4) The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.
 - (5) The control shall include an amber common warning indication lamp.
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- (6) The generator set control shall indicate the existence of the warning and shutdown conditions on the control panel. All conditions indicated below for warning shall be field-configurable for shutdown. Conditions required to be annunciated shall include:
 - (A) low oil pressure (warning).
 - (B) low oil pressure (shutdown).
 - (C) oil pressure sender failure (warning).
 - (D) low coolant temperature (warning).
 - (E) high coolant temperature (warning).
 - (F) high coolant temperature (shutdown).
 - (G) high oil temperature (warning).
 - (H) engine temperature sender failure (warning).
 - (I) low coolant level (warning).
 - (J) fail to crank (shutdown).
 - (K) fail to start/overcrank (shutdown).
 - (L) overspeed (shutdown).
 - (M) low DC voltage (warning).
 - (N) high DC voltage (warning).
 - (O) weak battery (warning).
 - (P) low gas pressure (warning).
 - (Q) high AC voltage (shutdown).
 - (R) low AC voltage (shutdown).
 - (S) under frequency (shutdown).
 - (T) over current (warning).
 - (U) over current (shutdown).
 - (V) short circuit (shutdown).
 - (W) over load (warning).
 - (X) emergency stop (shutdown).
 - (Y) natural gas supply valve(s) closed.
 - (Z) (4) configurable conditions
 - (7) Provisions shall be made for indication of four customer specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.
- 2.6.4 Engine Status Monitoring.
- 2.6.4.1 The following information shall be available from a digital status panel on the generator set control:
- (1) engine oil pressure (psi or kPa).
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- (2) engine coolant temperature (degrees F or C).
 - (3) engine oil temperature (degrees F or C).
 - (4) engine speed (rpm).
 - (5) number of hours of operation (hours).
 - (6) number of start attempts.
 - (7) battery voltage (DC volts).
 - 2.6.4.2 The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications.
 - 2.6.5 Engine Control Functions.
 - 2.6.5.1 The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15 second rest period between cranking periods.
 - 2.6.5.2 The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
 - 2.6.5.3 The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
 - 2.6.5.4 The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
 - 2.6.5.5 The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.
 - 2.6.6 Alternator Control Functions:
 - 2.6.6.1 The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.
 - 2.6.6.2 Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to
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- the requirements of NFPA 70 article 445. The protection for this function shall be 3rd party certified to very performance.
- 2.6.6.3 Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA 70 article 445. The protection for this function shall be 3rd party certified to very performance.
 - 2.6.6.4 Controls shall be provided to monitor the kW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
 - 2.6.6.5 A line to neutral sensing AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.
 - 2.6.6.6 The generator set control shall include a 120 VAC control heater.
- 2.6.7 Other Control Functions
- 2.6.7.1 The generator set shall be provided with a network communication module to allow LonMark compliant communication with the generator set control by remote devices. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network in both test and emergency modes.
 - 2.6.7.2 A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25 VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

2.7 OTHER EQUIPMENT TO BE PROVIDED WITH THE GENERATOR SET

- 2.7.1 Control Interfaces for Remote Monitoring:
 - 2.7.1.1 The control system shall provide four programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, (4) load shed command.
 - 2.7.1.2 A fused 10 A switched 24 VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
 - 2.7.1.3 A fused 10 A, 24 VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.
 - 2.7.1.4 The control shall be provided with a direct serial communication link for the LonWorks communication network interface as described elsewhere in this specification and shown on the drawings.
 - 2.7.2 Provide and install a 20-light LED type remote alarm annunciator with horn, located as shown on the drawings or in a location that can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called
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for by NFPA Standard 110 for level 1 systems for the local generator control panel. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp colour shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has been cleared, in compliance with NFPA 110 3-5.6.2. The interconnecting wiring between the annunciator and other system components shall be monitored and failure of the interconnection between components shall be displayed on the annunciator panel.

- 2.7.3 The annunciator shall include the following alarm labels, audible annunciation features, and lamp colours:

Condition	Lamp Colour	Audible Alarm
Normal Power (to Loads)	Green	No
Genset Supplying Load	Amber	No
Genset Running	Green	No
Not in Auto	Red (Flashing)	Yes
High Battery Voltage	Red	Yes
Low Battery Voltage	Red	Yes
Charger AC Failure	Red	Yes
Fail to Start	Red	Yes
Low Engine Temperature	Amber	Yes
Pre-High Engine Temperature	Amber	Yes
High Engine Temperature	Red	Yes
Pre-Low Oil Pressure	Amber	Yes
Low Oil Pressure	Red	Yes
Overspeed	Red	Yes
Low Coolant Level	Amber	Yes
Low Fuel Pressure	Amber	Yes
Network OK	Green	Yes
Natural gas supply valve closed	Red	Yes
(4) Spares	Configurable	Configurable

- 2.7.4 Low battery voltage lamp shall also be lighted for low cranking voltage or weak battery alarm.

- 2.7.5 The generator set shall be provided with a mounted main line circuit breaker, sized to carry the rated output current of the generator set. The circuit breaker shall incorporate an electronic trip unit that operates to protect the alternator under all overcurrent conditions, or a thermal-magnetic trip with other overcurrent protection devices that positively protect the alternator under overcurrent conditions. The supplier shall submit time overcurrent characteristic curves and thermal damage curve for the alternator, demonstrating the effectiveness of the protection provided.

2.8 CIRCUIT BREAKERS

- 2.8.1 CSA C22.2 No. 5, molded case circuit breakers on generator output with integral thermal and instantaneous magnetic trip in each pole, sized to CSA C22.1. Include battery-voltage operated shunt trip, connected to open circuit breakers on engine failure. Unit mount in enclosure to meet CSA C22.2 No. 100, Type 1 requirements.
- 2.8.2 Bolt-on, molded case, temperature compensated for 40°C ambient, dual thermal-magnetic trip. Electronic trip type with adjustments for long-time, instantaneous, and short-time functions.

- 2.8.3 Interrupting capacity: To suit available fault current from Generator set alternator.
 - 2.8.3.1 Minimum 25 kA IC.
 - 2.8.3.2 The emergency generator main overcurrent device shall be coordinated with the overcurrent devices of feeders and branch circuits downstream in accordance with CSA C282 and in accordance with the Coordination Study specified in Section 26 05 73.16.
- 2.8.4 Schedule of generator output circuit breakers:
 - 2.8.4.1 Generator Output Breaker to feed emergency terminals of Automatic Transfer Switches.
 - 2.8.4.2 Load Bank Breaker
 - (1) Rating and ampacity of load bank breaker to match generator output breaker.
 - (2) Equipped with shunt trip capability to ensure that the breaker will be tripped during testing upon receiving engine start signal from Automatic Transfer Switch. Electrical contractor to provide cables from each Automatic Transfer Switch to breaker to suit manufacturer's instructions.
 - (3) Provide lugs allowing ease of connection for load bank cables.

2.9 REMOTE ANNUNCIATION AND MONITORING

- 2.9.1 Provide remote annunciator panel for field installation by installing Contractor.
- 2.9.2 Provide NIC Card for SNMP Monitoring.
- 2.9.3 Provide BACnet/BACnet-IP and other interface required in order to connect the generator control panel to the Building Automation System. The BAS must be able to read all the monitoring and operation signals from genset. Provide all the conduit and wires to the BAS panel and coordinate with Division 25 for final connection. At a minimum, include the following:
 - 2.9.3.1 ON/OFF status.
 - 2.9.3.2 Oil Pressure.
 - 2.9.3.3 Coolant Level.
 - 2.9.3.4 Coolant temperature.
 - 2.9.3.5 Oil Temperature.
 - 2.9.3.6 Up to 10 additional points should be allowed to be programmable for Generator on the BAS.
- 2.9.4 The Generator graphics should also be included on the BAS with the points listed above.
- 2.9.5 Coordinate with Division 25 to ensure necessary critical alarm parameters are programmed to allow alarms to be sent to relevant stakeholders via email.

2.10 WEATHERPROOF SKIN-TIGHT ENCLOSURE

- 2.10.1 Sound attenuating enclosure with sound attenuation to provide sound levels of no greater than 75 dB(A) at 7 m perimeter.
- 2.10.2 To suit conduit entry from below grade.
- 2.10.3 Access doors with key locks, welded hinges, and door lock port hole to keep door open during maintenance. Maximum access door width 1000 mm.
- 2.10.4 Primed for corrosion protection and finish painted in a custom colour to be selected by the Owner and confirmed at submittal review.
- 2.10.5 Interior of enclosure to consist of high reflectance materials to improve light levels when servicing or maintaining unit.
- 2.10.6 Maximum Dimensions:
 - 2.10.6.1 Length: 7137 mm.
 - 2.10.6.2 Width: 2252 mm.

2.10.6.3 Height: 3281 mm.

2.11 ACCESSORIES

2.11.1 Factory provided accessories in the generator enclosure prewired to a panelboard in the generator enclosure:

2.11.1.1 Heating:

- (1) Battery thermal wrap, 120 V, minimum 75 W per battery to maintain battery temperature of 27°C (80°F), and complete with thermostat to eliminate batter damage caused by overheating or acid spill.
(A) Basis of design: HOTSTART, Inc., BW series.
- (2) Motorized intake dampers, 5 kW 208 V 3-phase forced flow heater in enclosure complete with reverse acting thermostat for control to maintain 10°C at all times.
- (3) Engine block circulating coolant heater with thermostat, 5 kW, 208 V, 1-phase, or sized to engine manufacturer's recommendations if a larger size is required.
- (4) Regulator heater.

2.11.1.2 Lighting:

- (1) Two LED strip luminaires 4100 lumen nominal, 3500 K CCT, standard driver, frosted lens, wire guard, and control.
(A) Signify FluxStream series.
(B) Substitution by Acuity Brands, Cree, Cooper Lighting Solutions, Hubbell, Visioneering.
- (2) Control for luminaires: white decorator style switch installed in surface mount utility box, complete with galvanized steel cover plate with rounded corners.
- (3) Emergency lighting battery unit complete with 2 hours runtime on loss of utility power and complete with two MR16 LED heads, light output equivalent to two 20 W MR16 incandescent lamps, in accordance with CSA C282 clause 6.11.1.
(A) Minimum illumination: 50 lx (5 fc).
(B) Battery units shall include automatic self-diagnostic circuitry, and a transient voltage surge suppressor on the supply site of power to the unit.
(C) Battery unit to be complete with CSA 5-15 plug and plugged into a dedicated emergency lighting receptacle installed immediately adjacent to the battery unit.

2.11.1.3 120 V battery charger with discharge and recharge rates to comply with CSA C282.

2.11.1.4 Minimum one 5-15R GFI duplex receptacle on generator (in addition to the battery unit receptacle).

2.11.1.5 If spring isolators are to be used, provide generator frame-bottom metal sealing plate to maintain heat inside enclosure, proper directionality of airflow, maintain noise rating, and prevent animal ingress.

2.11.1.6 Other accessories as indicated on the generator enclosure layout drawing, and as required for a complete operating system, and as recommended by the generator manufacturer.

- 2.11.1.7 Accessories to be fed from a panelboard pre-installed within the generator enclosure, rated 60 A 120/208 V, 1-Ph, 3W, 10 kA IC, complete with main breaker, and complete with full size, bolt-on breakers, installed with vibration isolation from the generator enclosure.
 - (1) Plug-on breaker panelboard, or panelboard installed outside the skin-tight enclosure, or use of tandem circuit breakers will be rejected, and field replaced at manufacturer's expense.
 - (2) Acceptable panelboard and circuit breaker manufacturers:
 - (A) Eaton PRL1 series.
 - (B) Schneider Electric NQ series.
 - (C) Siemens equal.
 - (3) Provide a minimum of one (1) spare 15 A single pole breaker.
- 2.11.2 Supplier to include an inspection for unit enclosure and generator accessories by the Electrical Authority Having Jurisdiction (ESA in Ontario) prior to shipment to site. Submit ESA inspection report to the Consultant.

2.12 SEQUENCE OF OPERATION

- 2.12.1 Start generator set on receipt of a start signal from remote equipment (automatic transfer switch). The start signal shall be via hardwired connection to the generator set control and a redundant signal over the required network connection.
 - 2.12.2 Start generator and be connected to life safety equipment within 15 s of loss of normal power including the time delays for ATS "override momentary normal source outages", generator start-up time, and ATS "transfer to emergency" time delays.
 - 2.12.3 The generator set shall complete a time delay start period as programmed into the control.
 - 2.12.4 The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:
 - 2.12.4.1 The control system shall verify that the engine is rotating when the starter is signalled to operate. If the engine does not rotate after three attempts, the control system shall shut down and lock out the generator set, and indicate "fail to crank" shutdown.
 - 2.12.4.2 The engine shall start and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate "fail to start".
 - 2.12.4.3 The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
 - 2.12.5 On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous, synchronize, load share, load demand, or load govern state.
 - 2.12.6 When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
 - 2.12.7 On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.
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- 2.12.7.1 Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

2.13 SOURCE QUALITY CONTROL

- 2.13.1 Provide factory test, start-up by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.
- 2.13.2 The generator set manufacturer shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided to the Consultant. All testing shall be performed with calibrated metering.
- 2.13.3 Factory testing may be witnessed by the Owner and the Consultant. Costs for travel expenses will be the responsibility of the Owner and the Consultant. Supplier is responsible to provide two weeks notice for testing.
- 2.13.4 Generator set factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include:
- 2.13.4.1 4 hour run at full load.
- 2.13.4.2 Maximum power.
- 2.13.4.3 Voltage regulation.
- 2.13.4.4 Transient and steady-state governing.
- 2.13.4.5 Single step load pickup:
- (1) Zero to 100% to zero.
- (2) Zero to 75% to zero.
- (3) Zero to 50% to zero.
- (4) Zero to 25% to zero.
- 2.13.4.6 Function of safety shutdowns.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to final testing of the system.
- 3.1.2 Remove battery from emergency lighting equipment and store indoors in a climate controlled area prior to installation of the generator set.

3.2 PREPARATION

- 3.2.1 Location of generator in accordance with the National Fire Code of Canada:
- 3.2.1.1 Locate at a minimum distance of 1 m to a building on the same property.
- 3.2.1.2 Locate at a minimum distance of 1 m to a property line.
- 3.2.1.3 Located such that the exhaust vent or chimney is minimum 3 m (10 ft) from any building.

3.3 INSTALLATION

- 3.3.1 Install equipment in accordance with final submittals and contract documents. Comply with applicable provincial and local codes as required by the Authority Having Jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of CSA listed products.
- 3.3.2 Perform Work to CSA C22.1.
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- 3.3.3 Conform to CSA C282 and CSA B149.1.
- 3.3.4 Concrete housekeeping pad:
 - 3.3.4.1 Install generator on concrete housekeeping pads designed by Structural Engineer to Section 03 30 00.
 - 3.3.4.2 Cast-in-place concrete housekeeping pad to extend a minimum of 1 m beyond footprint of generator.
 - 3.3.4.3 Coordinate exact conduit entry point with equipment submittals prior to fabricating pad.
 - 3.3.4.4 Sleeve conduit stubs and caulk conduits after concrete pour.
 - 3.3.4.5 Permanently fasten equipment to the pad in accordance with manufacturer's instructions and seismic requirements of the site.
- 3.3.5 Provide all interconnecting wiring between all major equipment provided for the on-site power system. Provide interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
- 3.3.6 Provide a minimum 60 A, 2-wire plus neutral plus ground feeder, fed from a 60A/2P breaker in the local 120/208 V emergency receptacle panel to feed generator accessory panel, unless noted otherwise by the manufacturer.
- 3.3.7 Install remote annunciator adjacent to the automatic transfer switch, or as noted on drawings.
- 3.3.8 Systems Integration:
 - 3.3.8.1 Use stranded conductors to signals from Automatic Transfer Switch in Section 26 36 23.13:
 - (1) Start/stop.
 - (2) Connect the ATS in bypass signal to the generator control panel.
 - 3.3.8.2 Fire Alarm System Supervision: Use stranded conductors to connect to Fire Alarm System per Section 28 46 13 for the following signals:
 - (1) Common generator fault condition (including main disconnect open) to provide a supervisory signal at the fire alarm system.
 - (2) Generator Running (non-latching monitoring signal).
 - (3) Any natural gas valves supplying the generator closed.
 - (4) Not in auto.

3.4 GROUNDING AND BONDING (3-POLE ATS)

- 3.4.1 Ground and bond to Electrical Code requirements, and Section 26 05 26.
- 3.4.2 Remove bonding jumper from generator neutral to suit 3-pole ATS.
- 3.4.3 For 3-pole transfer switches utilized on 4-wire systems with unswitched neutrals, provide warning sign at the generator to clearly indicate the use of a floating neutral and that the generator neutral is not separately grounded.

3.5 FIELD QUALITY CONTROL

- 3.5.1 Inspect equipment for physical damage. Repair scratches and other installation damage prior to final system testing. Thoroughly clean equipment to remove all dirt and construction debris prior to initial operation and final testing of the system.
 - 3.5.2 Manufacturer Services:
 - 3.5.2.1 On completion of the installation, conduct a site evaluation to verify that the equipment is installed per manufacturer's recommended practice.
 - 3.5.2.2 Equipment shall be initially started and operated by representatives of the manufacturer. All protective settings shall be adjusted as instructed by the Consultant.
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- 3.5.3 Inspections
 - 3.5.3.1 Complete all verifications, inspections, and reports prior to scheduling TSSA inspection.
 - 3.5.3.2 Carry for the cost of all inspections by authorities having jurisdiction, including, but not limited to, the Electrical Safety Authority (ESA), and Technical Standards Safety Authority (TSSA).
 - 3.5.3.3 Carry the cost of all TSSA variances, or as detailed in CSA B149.1.
 - 3.5.3.4 Confirm the emergency lighting unit is fully operational.
- 3.5.4 On Site Acceptance Test
 - 3.5.4.1 The complete installation shall be tested to verify compliance with the performance requirements of this specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer. Notify the Consultant in advance of the test for the option to witness the tests. The generator set manufacturer shall provide a site test specification covering the entire system.
 - 3.5.4.2 Prior to start of active testing, all field connections for wiring, power conductors, and bus bar connections shall be checked for proper tightening torque.
 - 3.5.4.3 Installation acceptance tests to be conducted on-site shall include a "cold start" test, a 4 hour full load (resistive) test, and a one step rated load pickup test in accordance with CSA C282. Provide a resistive load bank and make temporary connections for full load test, if necessary.
 - 3.5.4.4 Perform a power failure test on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.
 - 3.5.4.5 The generator set supplier shall issue a test report documenting the results of testing, and including a complete list of all settings in the control system.
- 3.5.5 Provide labour and material to conduct the integrated systems testing of interconnected life safety systems in accordance with CAN/ULC-S1001-11.

3.6 TRAINING

- 3.6.1 The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the Owner.
 - 3.6.2 Familiarize the Owner's Representative in the testing and maintenance requirements prescribed by Ontario Regulations, O.Reg 524/98:
 - 3.6.2.1 The system shall be used and operated for the purpose of testing or performing maintenance for a maximum of 60 hours in any 12 month period.
 - 3.6.2.2 The system shall be used and operated for the purpose of testing or performing maintenance only between the hours of 7 a.m. and 7 p.m.
 - 3.6.2.3 When the system is used and operated for the purpose of testing or performing maintenance, the air intakes, doors and windows of any buildings or structures located on the same site as the system shall be closed, if doing so would reduce the likelihood of emissions from the system entering the building or structure.
 - 3.6.2.4 If more than one generator unit is part of the system, only one unit shall be used and operated at any time for the purpose of testing or performing maintenance.
 - 3.6.2.5 If the Ministry of the Environment issues a smog advisory that identifies an area in which the system is located, the system shall not be used or operated for the purpose of testing or performing maintenance until a termination notice with respect to the advisory has been issued for that area.
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3.7 *MAINTENANCE*

3.7.1 Perform equipment maintenance as described in PART 1 of this section.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Provide complete factory assembled power transfer equipment with field programmable digital electronic controls designed for fully automatic operation and including, voltage sensors on all phases of both sources, linear operator, permanently attached manual handles, positive mechanical and electrical interlocking, and mechanically held contacts for both sources.
- 1.1.2 The Automatic Transfer Switch will transfer the load in delayed transition (break and delay-before-make) mode.
- 1.1.3 Automatic transfer switches are to be electrically operated, mechanically held open contact type, without integral overcurrent protection. Transfer switches utilizing automatic or non-automatic molded case circuit breakers as switching mechanisms are not acceptable.
- 1.1.4 The transfer switch shall feature a double-sided bypass isolation mechanism.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 08 36 – Performance Checklist for Automatic Transfer Switches.
- 1.2.2 Section 26 32 13.16 – Gas-Engine-Driven Generator Sets.
- 1.2.3 Section 28 46 13 – Fire-Alarm Systems.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 5:16 (R2021), Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures (Tri-national standard with UL 489, NMJ-J-266-ANCE-2010).
 - 1.3.1.4 CSA C22.2 No. 178.1-14 (R2019), Transfer Switch Equipment.
 - 1.3.1.5 CSA C282:19, Emergency Electrical Power Supply for Buildings.
 - 1.3.1.6 CAN/CSA C60044-1-07 (R2011), Instrument Transformers.
- 1.3.2 IEEE
 - 1.3.2.1 IEEE 446, Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications.
- 1.3.3 National Electrical Manufacturers Association (NEMA)
 - 1.3.3.1 ANSI/NEMA ICS 2-1996(R2009), Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC, Part 8: Disconnect Devices for Use in Industrial Control Equipment.
 - 1.3.3.2 NEMA ICS 1 - General Standards for Industrial Control and Systems.
 - 1.3.3.3 NEMA ICS 2 -Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
 - 1.3.3.4 NEMA ICS 6 - Industrial Controls and Systems: Enclosures.
 - 1.3.3.5 NEMA ICS 10-1993, AC Automatic Transfer Switches.

1.4 ALTERNATES

- 1.4.1 Submit bid based on automatic transfer switch manufactured by ASCO.
 - 1.4.2 The bidder may submit with bid an alternative price indicating the credit to substitute with an automatic transfer switch as manufactured by other manufacturers listed in part 2 of
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this section. Indicate the proposed substitute manufacturer on the bid form if the alternative price is submitted.

1.5 ACTION SUBMITTALS

- 1.5.1 Within ten days after award of contract, provide electronic copies of the following information for review:
- 1.5.2 Product Data:
 - 1.5.2.1 Submit manufacturer's instructions, printed product literature and data sheets for transfer switches and include product characteristics, performance criteria, physical size, finish, and limitations, including voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, short circuit ratings, dimensions, weights, and enclosure details.
 - 1.5.2.2 A copy of the markings that are to appear on the transfer switches when installed.
 - 1.5.2.3 Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
 - 1.5.2.4 Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
 - 1.5.2.5 Manufacturer's certification of prototype testing.
 - 1.5.2.6 Manufacturer's published warranty documents.
- 1.5.3 Shop Drawings:
 - 1.5.3.1 Indicate on drawings:
 - (1) Make, model and type.
 - (2) Single line diagram showing controls and relays.
 - (3) Description of equipment operation including:
 - (A) Automatic starting and transfer to standby unit and back to normal power.
 - (B) Test control.
 - (C) Manual control.
 - (D) Automatic shutdown.
 - 1.5.3.2 Submit drawing of the engraved phenolic equipment nameplate.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 Provide operation and maintenance data for automatic load transfer equipment for incorporation into manual specified in Section 01 77 00. Make prints of electronic submittals.
 - 1.6.2 Operation and Maintenance Data: submit operation and maintenance data for transfer switches for incorporation into manual.
 - 1.6.3 Detailed instructions to permit effective operation, maintenance and repair.
 - 1.6.4 Technical data:
 - 1.6.4.1 Schematic diagram of components, controls and relays.
 - 1.6.4.2 Illustrated parts lists with parts catalogue numbers.
 - 1.6.4.3 Certified copy of factory test results.
 - 1.6.5 On-site commissioning and functional testing reports.
 - 1.6.6 Warranty card, specifying the warranties for all ATS's.
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1.7 OPERATIONS AND MAINTENANCE DATA

- 1.7.1 Operation Data: Include instructions for operating equipment. Include instructions for operating equipment under emergency conditions.
- 1.7.2 Maintenance Materials:
 - 1.7.2.1 Include routine preventative maintenance and lubrication schedule.
 - 1.7.2.2 List special tools, maintenance materials, and replacement parts, or indicate if there are no special tools or user serviceable parts.
 - 1.7.2.3 Provide two of each special tool required for maintenance, if applicable.

1.8 QUALITY ASSURANCE

- 1.8.1 Manufacturer Qualifications
 - 1.8.1.1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, and with service facilities to respond in timely manner.
 - 1.8.1.2 Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience.
 - 1.8.1.3 The manufacturer of the transfer switch shall maintain service parts inventory at a central location which is accessible to the service location 24 hours/day, 365 days/year.
 - 1.8.1.4 The transfer switch shall be serviced by a local service organization that is trained and factory certified in transfer switch service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours/day, 365 days/year.
 - 1.8.1.5 Manufacturer certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.
- 1.8.2 Regulatory Requirements
 - 1.8.2.1 Provide products listed and classified by CSA or testing firm acceptable to authority having jurisdiction as suitable for purpose specified and indicated.
 - 1.8.2.2 CSA listed and labeled.
 - 1.8.2.3 Meet all requirements as described in CSA C282.

1.9 DELIVERY, STORAGE, AND HANDLING

- 1.9.1 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- 1.9.2 Storage and Handling Requirements:
 - 1.9.2.1 Store materials indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - 1.9.2.2 Store and protect transfer switches from nicks, scratches, and blemishes.
 - 1.9.2.3 Replace defective or damaged materials with new.

1.10 FIELD MEASUREMENTS

- 1.10.1 Verify that field measurements are as indicated on shop drawings.

1.11 MAINTENANCE SERVICE

- 1.11.1 Provide service and maintenance of transfer switch for one year from date of Substantial Completion.
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1.12 WARRANTY

- 1.12.1 Minimum one year from the date of commissioning, warranted against defects in materials and workmanship.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 ASCO 7000 series automatic transfer and bypass isolation switch (basis of design).
- 2.1.2 Substitutions: in accordance with PART 1 article "ALTERNATES" from the list below:
- 2.1.2.1 Cummins Power Generation.
 - 2.1.2.2 Caterpillar.
 - 2.1.2.3 Eaton.
 - 2.1.2.4 Kohler Power Systems.

2.2 RATINGS

- 2.2.1 As indicated on single line diagram.
- 2.2.2 Minimum interrupting capacity per the following table, unless a higher value is indicated on the drawings:

<u>Switch Rating (Amps)</u>	<u>AIC Rating (kA)</u>
70 - 225	25
250	25
400	35
600, 800	65
1000, 1200	65
1600, 2000	65
2500, 3000	100
4000	100

2.3 SYSTEM DESCRIPTION

- 2.3.1 Automatic load transfer equipment to:
- 2.3.1.1 Monitor voltage on all phases of normal (utility) and emergency (generator) power sources.
 - 2.3.1.2 Initiate cranking of standby generator unit on normal power failure or abnormal voltage on any one phase below preset adjustable limits for adjustable period of time.
 - 2.3.1.3 Transfer load from normal supply to standby unit when standby unit reaches rated frequency and voltage pre-set adjustable limits.
 - 2.3.1.4 Transfer load from standby unit to normal power supply when normal power restored, confirmed by sensing of voltage on phases above adjustable pre-set limit for adjustable time period.
 - 2.3.1.5 Shut down standby unit after running unloaded to cool down using adjustable time delay relay.

2.4 AUTOMATIC TRANSFER AND BYPASS/ISOLATION SWITCH

- 2.4.1 Description: NEMA ICS 2, automatic transfer switch with manual bypass switch suitable for continuous operation.
- 2.4.2 Configuration: Draw-out type electrically-operated, mechanically-held transfer switch with manually-operated CONNECTED, TEST, AND DISCONNECTED draw-out positions, and
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with mechanically-operated, mechanically-held transfer switch connected to bypass automatic switch in both NORMAL and EMERGENCY positions.

- 2.4.3 The transfer switch shall feature a double sided bypass-isolation mechanism to allow power transfer switches to be inspected, tested, and maintained without any interruption of power to the load.
- 2.4.4 The isolate and bypass procedure shall not exceed 15 seconds.
- 2.4.5 Transfer switch shall permit bypass of the load to either source without load interruption.
- 2.4.6 Bypass Switch Ratings: Match automatic transfer switch for electrical ratings.
- 2.4.7 Transition: Delayed.

2.5 CONSTRUCTION

- 2.5.1 Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the source 1 and source 2 positions. The transfer switch shall be specifically designed to transfer to the best available source if it inadvertently stops in a neutral position.
- 2.5.2 Transfer switches shall be equipped with permanently attached manual operating handles and quick-break, quick-make over-center contact mechanisms.
- 2.5.3 Main switch contacts shall be high-pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover.
- 2.5.4 Transfer switch internal wiring shall be composed of pre-manufactured harnesses that are permanently marked for source and destination. Harnesses shall be connected to the control system by means of locking disconnect plugs, to allow the control system to be easily disconnected and serviced without disconnecting power from the transfer switch mechanism.
- 2.5.5 Power transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation but prevent direct contact with components that could be operating at line voltage levels.
- 2.5.6 Transfer switches shall be provided with a neutral bus and lugs. The neutral bus shall be sized to carry 100% of the current designated on the switch rating.
- 2.5.7 Provide sidecar where noted on floor plans.

2.6 ENCLOSURE

- 2.6.1 Enclosure: ICS 6, Type 1.
 - 2.6.2 Finish: Manufacturer's standard gray enamel.
 - 2.6.3 Maximum dimensions and space restrictions: refer to drawings.
 - 2.6.3.1 Ensure adequate space is available at sides and rear of the equipment as required to allow access during installation.
 - 2.6.4 Enclosures shall be UL listed. The enclosure shall provide wire bend space in compliance to the latest version of CSA standards. The cabinet door shall include permanently mounted key type latches.
 - 2.6.5 Transfer switch equipment shall be provided in a minimum NEMA 1 sprinklerproof enclosure.
 - 2.6.6 Enclosures shall be the NEMA type specified. The cabinet shall provide code-required wire bend space at point of entry as shown on the drawings. Manual operating handles and all control switches (other than key-operated switches) shall be accessible to authorized personnel only by opening the key-locking cabinet door. Transfer switches with manual operating handles and/or non key-operated control switches located on outside of cabinet do not meet this specification and are not acceptable.
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- 2.6.7 Enclosure shall be complete with wireway as required to accept top, side, or bottom cable entry.

2.7 CONNECTIONS

- 2.7.1 Field control connections shall be made on a common terminal block that is clearly and permanently labeled.
- 2.7.2 Transfer switch shall be provided with mechanical lugs suitable for copper conductors and sized to accept the full output rating of the switch.
- 2.7.3 Lugs suitable for multiple parallel runs of conductors.
- 2.7.4 Contractor to field verify exact size and quantity of existing conductors.

2.8 SERVICE CONDITIONS

- 2.8.1 Transfer switches rated to carry 100 per cent of rated current continuously in the enclosure supplied, in ambient temperatures of -40°C to +60°C, relative humidity up to 95 per cent non-condensing, and altitudes up to 3000 m (10 000 feet).

2.9 MATERIALS

- 2.9.1 Instrument transformers: to CAN/CSA C60044-1.
- 2.9.2 Contactors: to NEMA ICS2.

2.10 CONTROLS AND INDICATORS

- 2.10.1 Selector switches:
- 2.10.1.1 2 position for system test with load "Test", "Auto"
 - 2.10.1.2 3 position for generator control "Auto", "Manual", "Engine Start"
 - 2.10.1.3 Test position - normal power failure simulated. Engine starts and transfer takes place. Return switch to "Auto" to stop engine.
 - 2.10.1.4 Auto position - normal operation of transfer switch on failure of normal power; retransfers on return of normal voltage and shuts down engine.
 - 2.10.1.5 Manual position - transfer switch may be operated by manual handle but transfer switch will not operate automatically and engine will not start.
 - 2.10.1.6 Engine start position - engine starts but unit will not transfer unless normal power supply fails. Switch must be returned to "Auto" to stop engine.
- 2.10.2 Control transformers: dry type with 120 V secondary to isolate control circuits from:
- 2.10.2.1 Normal power supply.
 - 2.10.2.2 Emergency power supply.
- 2.10.3 Relays: continuous duty, industrial control type, with wiping action contacts rated 10 A minimum:
- 2.10.3.1 Voltage sensing: 3 phase for normal power and on three phases for emergency, solid state type, adjustable drop out and pick up, close differential, 2 V minimum undervoltage and over voltage protection.
 - 2.10.3.2 Time delays as indicated in the Sequence of Operation section.
 - 2.10.3.3 Frequency sensing, to prevent transfer from normal power supply until frequency of standby unit reaches preset adjustable values.
- 2.10.4 Product Options and Features
- 2.10.4.1 Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, SWITCH POSITION, NORMAL BYPASS, ALTERNATE SOURCE BYPASS.
 - 2.10.4.2 Test Switch: Mount in cover of enclosure to simulate failure of normal source.
 - 2.10.4.3 Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate to normal source.
 - 2.10.4.4 Transfer Switch Auxiliary Contacts: two normally open; two normally closed.
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- 2.10.4.5 Normal Source Monitor: Monitor each line of normal source voltage and frequency; initiate transfer when voltage drops below 85 percent or frequency varies more than 3 percent from rated nominal value.
 - 2.10.4.6 Alternate Source Monitor: Monitor alternate source voltage and frequency; inhibit transfer when voltage is below 85 percent or frequency varies more than 3 percent from rated nominal value.
 - 2.10.5 Operator Panel. Each transfer switch shall be provided with a control panel to allow the operator to view the status and control operation of the transfer switch. The operator panel shall be a sealed membrane panel rated NEMA 3R/IP53 or better that is permanently labeled for switch and control functions. The operator panel shall be provided with the following features and capabilities.
 - 2.10.5.1 High intensity LED lamps to indicate the source that the load is connected to (source 1 or source 2); and which sources are available. Source available LED indicators shall operate from the control microprocessor to indicate the true condition of the sources as sensed by the control.
 - 2.10.5.2 High intensity LED lamps to indicate that the transfer switch is "not in auto" (due to control being disabled or due to bypass switch enabled or in operation) and "Test/Exercise Active" to indicate that the control system is testing or exercising the generator set.
 - 2.10.5.3 "OVERRIDE" pushbutton to cause the transfer switch to bypass any active time delays for start, transfer, and retransfer and immediately proceed with its next logical operation.
 - 2.10.5.4 "TEST" pushbutton to initiate a pre-programmed test sequence for the generator set and transfer switch. The transfer switch shall be programmable for test with load or test without load.
 - 2.10.5.5 "LAMP TEST" pushbutton(s) to test all lamps on the panel by lighting them, either simultaneously from one control, or individually.
 - 2.10.5.6 The control system shall continuously log information on the number of hours each source has been connected to the load, the number of times transferred, and the total number of times each source has failed. This information shall be available via a PC-based service tool or an operator display panel.
 - 2.10.5.7 Security Key Switch or password on control panel to allow the user to inhibit adjustments.
 - 2.10.5.8 Key operated test operator switch to prevent manual operation or testing of the transfer switch unless key is in place and operated.
 - 2.10.5.9 Digital AC meter display panel, to display 3-phase AC Volts, Hz, kW load level, and load power factor. The display shall be colour-coded, with green scale indicating normal or acceptable operating level, yellow indicating conditions nearing a fault, and red indicating operation in excess of rated conditions for the transfer switch.
 - 2.10.5.10 Vacuum fluorescent or LCD alphanumeric display panel with push-button navigation switches. The display shall be clearly visible in both bright (sunlight) and no light conditions. It shall be visible over an angle of at least 120°. The Alphanumeric display panel shall be capable of providing the following functions and capabilities:
 - (1) Display source condition information, including AC voltage for each phase of normal and emergency source, frequency of each source. Voltage for all three phases shall be displayed on a single screen for easy viewing of voltage balance.
 - (2) Display source status, to indicate source is connected or not connected.
 - (3) Display load data, including 3-phase AC voltage, 3-phase AC current, frequency, kW, kVA, and power factor. Voltage and current data for all phases shall be displayed on a single screen.
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- (4) The display panel shall allow the operator to view and make the following adjustments in the control system, after entering an access code:
 - (A) Adjust voltage and frequency sensor operation set points.
 - (B) Set up time clock functions.
 - (C) Set up load sequence functions.
 - (D) Enable or disable control functions in the transfer switch, including program transition.
 - (E) Set up exercise and load test operation conditions, as well as normal system time delays for transfer time, time delay start, stop, transfer, and retransfer.
- (5) Display Real time Clock data, including date, and time in hours, minutes, and seconds. The real time clock shall incorporate provisions for automatic daylight savings time and leap year adjustments. The control shall also log total operating hours for the control system.
- (6) Display service history for the transfer switch. Display source connected hours, to indicate the total number of hours connected to each source. Display number of times transferred, and total number of times each source has failed.
- (7) Display fault history on the transfer switch, including condition, date/time of fault. Faults to include controller checksum error, low controller DC voltage, ATS fail to close on transfer, ATS fail to close on retransfer, battery charger malfunction, network battery voltage low, network communications error.

2.10.6 Internal Controls

- 2.10.6.1 Provide RMS voltage sensing and metering that is accurate to within plus or minus 1% of nominal voltage level. Frequency sensing shall be accurate to within plus or minus 0.2%. Voltage sensing shall be monitored based on the normal voltage at the site. Systems that utilize voltage monitoring based on standard voltage conditions that are not field configurable are not acceptable.
 - 2.10.6.2 Transfer switch voltage sensors shall be close differential type, providing source availability information to the control system based on the following functions:
 - (1) Monitoring all phases of the normal service (source 1) for under voltage conditions (adjustable for pickup in a range of 85 to 98% of the normal voltage level and dropout in a range of 75 to 98% of normal voltage level).
 - (2) Monitoring all phases of the emergency service (source 2) for under voltage conditions (adjustable for pickup in a range of 85 to 98% of the normal voltage level and dropout in a range of 75 to 98% of pickup voltage level).
 - (3) Monitoring all phases of the normal service (source 1) and emergency service (source 2) for voltage imbalance.
 - (4) Monitoring all phases of the normal service (source 1) and emergency service (source 2) for loss of a single phase.
 - (5) Monitoring all phases of the normal service (source 1) and emergency service (source 2) for phase rotation.
 - (6) Monitoring all phases of the normal service (source 1) and emergency service (source 2) for over voltage conditions (adjustable for dropout over
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a range of 105 to 135% of normal voltage, and pickup at 95-99% of dropout voltage level).

- (7) Monitoring all phases of the normal service (source 1) and emergency service (source 2) for over or under frequency conditions.
- (8) Monitoring the neutral current flow in the load side of the transfer switch. The control shall initiate an alarm when the neutral current exceeds a preset adjustable value in the range of 100-150% of rated phase current for more than an adjustable time period of 10 to 60 seconds.

- 2.10.6.3 All transfer switch sensing shall be configurable from the Transfer Switch or a Remote PC-based service tool, to allow setting of levels, and enabling or disabling of features and functions. Selected functions including voltage sensing levels and time delays shall be configurable using the operator panel. Designs utilizing DIP switches or other electromechanical devices are not acceptable. The transfer control shall incorporate a series of diagnostic LED lamps.
- 2.10.6.4 The transfer switch shall be configurable to control the operation time from source to source (program transition operation). The control system shall be capable of enabling or disabling this feature, and adjusting the time period to a specific value. A phase band monitor or similar device is not acceptable.
- 2.10.6.5 The transfer switch shall incorporate adjustable time delays for generator set start (adjustable in a range from 0-15 seconds); transfer (adjustable in a range from 0-120 seconds); retransfer (adjustable in a range from 0-30 minutes); and generator stop (cool-down) (adjustable in a range of 0-30 minutes).
- 2.10.6.6 The transfer switch shall be configurable to accept a relay contact signal and a network signal from an external device to prevent transfer to the generator service.
- 2.10.6.7 The control system shall be designed and prototype tested for operation in ambient temperatures from -40°C to +70°C. It shall be designed and tested to comply with the requirements of the noted voltage and RFI/EMI standards.
- 2.10.6.8 The control shall have optically isolated logic inputs, high isolation transformers for AC inputs, and relays on all outputs, to provide optimum protection from line voltage surges, RFI and EMI.

2.11 ACCESSORIES

- 2.11.1 Ensure pilot lights indicate power availability normal and standby, switch position, green for normal, red for standby, mounted in panel.
- 2.11.2 Plant exerciser.
- 2.11.3 Auxiliary Relays:
 - 2.11.3.1 Auxiliary relays to provide normally open (NO) and normally closed (NC) contacts for remote alarms.
 - 2.11.3.2 The transfer switch will provide the following dry contact monitoring points to determine status of the ATS remotely:
 - (1) Normal power available
 - (2) Emergency power available
 - (3) ATS in "Normal" position
 - (4) ATS in "Emergency" position
 - (5) ATS "Not in Auto"
 - (6) Pre-transfer
 - (7) Failure to Synchronize

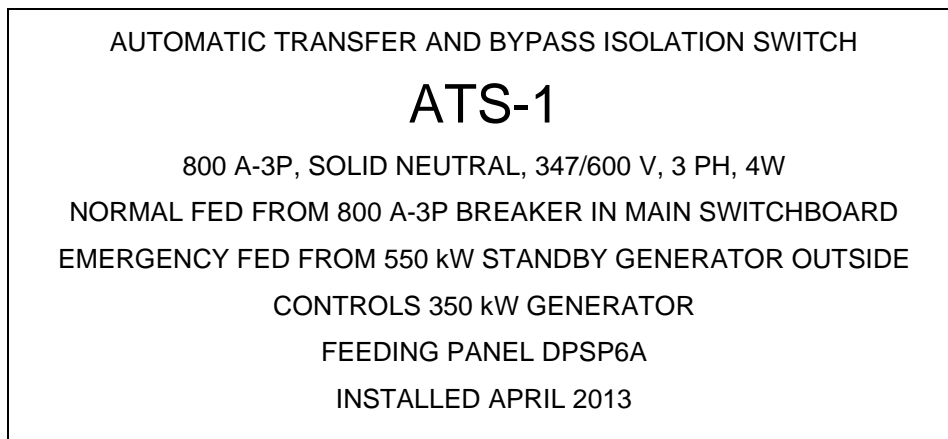
- (8) Extended Parallel Alarm
 - 2.11.4 Instruments:
 - 2.11.4.1 Digital true RMS, indicating type 2 per cent accuracy, flush panel mounting:
 - (1) Voltmeter: AC, scale 0 to nominal system voltage +10%.
 - (2) Ammeter: ac, scale 0 to 10% above continuous rating.
 - (3) Frequency meter: scale 55 Hz to 65 Hz.
 - (4) Voltmeter selector switch: rotary, maintained contacts, panel mounting type, round notched handle, four position, labelled "OFF-Phase A-Phase B-Phase C".
 - 2.11.5 Ammeter selector switch: rotary, maintained contacts, panel mounting type, designed to prevent opening of current circuits, round notched handle, four position labelled "OFF - Phase A - Phase B - Phase C".
 - 2.11.6 Bypass and Isolator
 - 2.11.6.1 A two-way bypass-isolation switch shall provide manual bypass of the load to either source and permit isolation of the automatic transfer switch from all source and load power conductors. All main contacts shall be manually driven.
 - 2.11.6.2 Power interconnections shall be silver-plated copper bus bar. The only field installed power connections shall be at the service and load terminals of the bypass-isolation switch. All control interwiring shall be provided with disconnect plugs.
 - 2.11.6.3 Separate bypass and isolation handles shall be utilized to provide clear distinction between the functions. Handles shall be permanently affixed and operable without opening the enclosure door. Designs requiring insertion of loose operating handles or opening of the enclosure door to operate are not acceptable.
 - 2.11.6.4 Bypass to the load-carrying source shall be accomplished with no interruption of power to the load (make before break contacts). Designs that disconnect the load when bypassing are not acceptable. The bypass handle shall have three operating modes: "Bypass to Normal," "Automatic," and "Bypass to Emergency." The operating speed of the bypass contacts shall be the same as the associated transfer switch and shall be independent of the speed at which the manual handle is operated. In the "Automatic" mode, the bypass contacts shall be out of the power circuit so that they will not be subjected to fault currents to which the system may be subjected.
 - 2.11.6.5 The isolation handle shall provide three operating modes: "Closed," "Test," and "Open." The "Test" mode shall permit testing of the entire emergency power system, including the automatic transfer switches with no interruption of power to the load. The "Open" mode shall completely isolate the automatic transfer switch from all source and load power conductors. When in the "Open" mode, it shall be possible to completely withdraw the automatic transfer switch for inspection or maintenance to conform to code requirements without removal of power conductors or the use of any tools.
 - 2.11.6.6 When the isolation switch is in the "Test" or "Open" mode, the bypass switch shall function as a manual transfer switch.
 - 2.11.6.7 Designs requiring operation of key interlocks for bypass isolation or ATSS which cannot be completely withdrawn when isolated are not acceptable.
 - 2.11.7 Communications Module
 - 2.11.7.1 The communications shall be capable of connecting to the Ethernet TCP/IP network with BacNet card for BAS communication. This module shall allow for the seamless integration of communication transfer devices.
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- 2.11.7.2 Allow remote viewing of transfer switch information from a PC, including transfer switch name, real time load in kW on the transfer switch, current source condition, and current operating mode.

2.12 EQUIPMENT IDENTIFICATION

- 2.12.1 Identify equipment in accordance with Section 26 05 53.
- 2.12.2 Control panel:
 - 2.12.2.1 For selector switch and manual switch: size 4 nameplates.
 - 2.12.2.2 For meters, indicating lights, minor controls: use size 3 nameplates.
- 2.12.3 Warning labels:
 - 2.12.3.1 For 3-pole transfer switches utilized on 4-wire systems with unswitched neutrals, provide warning sign on transfer switch to clearly indicate the use of a floating neutral and that the generator neutral is not separately grounded.
 - 2.12.3.2 For 4-pole transfer switches utilized on a 4-wire system with a switch neutral, provide warning sign on transfer switch to clearly indicate that each source is separately grounded.
- 2.12.4 Nameplates:
 - 2.12.4.1 Engraved phenolic nameplate, 3 mm (1/8 in) thick plastic engraved sheet.
 - 2.12.4.2 Red face, white core unless noted otherwise.
 - 2.12.4.3 To be mechanically attached with self-tapping screws.
 - 2.12.4.4 White letters, 12 mm (1/2 in.) high unless otherwise noted below.
 - 2.12.4.5 To include:
 - (1) Identity of equipment (i.e. ATS-1), 20 mm (3/4 in.) high letters.
 - (2) Voltage.
 - (3) Ampacity.
 - (4) Number of phases.
 - (5) Identity, switchboard section (if applicable), circuit number, and size of Normal Power source.
 - (6) Identity, switchboard section (if applicable), circuit number, and size of Emergency Power source.
 - (7) Identity of device or panelboard on the Load side of the transfer switch.
 - (8) Date of installation.
 - (9) If upstream or downstream device is located in a separate room from ATS, indicate the room name and number.
 - 2.12.4.6 Confirm exact colours and text with the engineer prior to fabrication.

2.12.4.7 Example of nameplate:



2.13 SOURCE QUALITY CONTROL

- 2.13.1 Complete equipment, including transfer mechanism, controls, relays and accessories factory assembled and tested in presence of the Consultant.
- 2.13.2 Notify Consultant 5 days minimum in advance of date of factory test.
- 2.13.3 Tests:
 - 2.13.3.1 Operate equipment both mechanically and electrically to ensure proper performance.
 - 2.13.3.2 Check selector switch, in modes of operation Test, Auto, Manual, Engine Start and record results.
 - 2.13.3.3 Check voltage sensing and time delay relay settings.
 - 2.13.3.4 Check:
 - (1) Automatic starting and transfer of load on failure of normal power.
 - (2) Retransfer of load when normal power supply resumed.
 - (3) Automatic shutdown.
 - 2.13.3.5 Provide copy of test reports and include with Commissioning Manual.

2.14 SEQUENCE OF OPERATION

- 2.14.1 The automatic and manual control of an emergency electrical power supply system, including the starting of a generator set or generator sets, and actuation of automatic transfer switches to connect a load to the emergency supply and reconnect it to the normal supply, shall be in the following sequence:
 - 2.14.1.1 Confirm initial set points with the Consultant prior to start up and commissioning.
 - 2.14.1.2 The generator sets shall be started when the normal supply at the transfer switch on one or more phase has been interrupted or is at a voltage that is less than 70 per cent of the nominal system voltage for 3 seconds.
 - (1) Initiate time delay to start alternate source engine generator: Upon initiation by normal source monitor.
 - (2) Time delay to start alternate source engine generator: 0 to 3 seconds, adjustable. Initial set point 3 seconds.
 - (3) Initiate transfer load to alternate source: Upon initiation by normal source monitor and permission by alternate source monitor.

- (4) Time delay before transfer to alternate power source: 0 to 60 minutes, adjustable.
 - (A) Initial set point for "Life Safety" transfer switches: zero (immediate transfer).
 - (B) Initial set point for "Non-Life Safety" transfer switches: 30 seconds.
 - (5) The set points for the items above shall be configured such that the generator is connected to and powering life safety equipment within 15 seconds of the loss of normal power.
 - 2.14.1.3 Where delayed emergency loads are arranged to be connected to the emergency supply later than the emergency loads, all of the delayed emergency loads and any other loads that have been arranged for connection at the same time.
 - 2.14.1.4 On restoration of the normal supply, and after nominal voltage and frequency have been maintained at nominal levels on all phases of the transfer switch for a period of 1 to 30 minutes, the automatic transfer switches shall transfer the loads back to the normal supply, except that the transfer shall occur without delay when an emergency supply fails.
 - (1) Initiate retransfer load to normal source: upon permission by normal source monitor.
 - (2) Time delay before transfer to normal power: 0 to 60 minutes, adjustable; bypass time delay in event of alternate source failure. Initial set point 15 minutes.
 - (3) Delayed transition duration: 0.5 to 3 seconds. Initial set point 0.5 seconds.
 - 2.14.1.5 After the transfer of loads back to the normal supply, the automatic shutdown of the generator set shall be delayed for 5 minutes or a reasonable length of time to stabilize the operating temperature under no-load conditions.
 - (1) Time delay before engine shut down: 0 to 60 minutes, adjustable, of unloaded operation. Initial set point 5 minutes.
 - 2.14.1.6 On a failure of normal power and a transfer to emergency power, the pre-transfer contacts shall be disabled and a transfer of the elevator load to the emergency power source shall take place without additional delay.
 - 2.14.1.7 On a retransfer from emergency power to normal power, the pre-transfer contacts shall inhibit a transfer to normal power for a minimum of 20 seconds.
 - 2.14.1.8 When the system is under test conditions in which both the normal and the emergency power sources are live, the pre-transfer contacts shall be enabled and shall inhibit a transfer to the emergency source for at least 20 seconds.
 - 2.14.2 Automatic engine exerciser:
 - 2.14.2.1 Engine Exerciser: Start engine every 7 days; run for 30 minutes before shutting down. Bypass exerciser control if normal source fails during exercising period.
 - 2.14.2.2 Alternate System Exerciser: Transfer load to alternate source during engine exercising period.
 - 2.14.2.3 Initial set point: turn off automatic engine exerciser.
 - 2.14.3 Generator Set Exercise (Test) With Load Mode. The control system shall be configurable to test the generator set under load. In this mode, the transfer switch shall control the generator set in the following sequence:
 - 2.14.3.1 Transfer switch shall initiate the exercise sequence at a time indicated in the exercise timer program, or when manually initiated by the operator.
 - 2.14.3.2 The transfer switch shall issue a compatible start command to the generator set, and cause the generator set to start and run at idle until it has reached normal operating temperature.
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- 2.14.3.3 When the generator set has reached normal operating temperature or after an adjustable time period (whichever is shorter), the control system shall accelerate the generator set to rated voltage and frequency.
- 2.14.3.4 When the control systems senses the generator set at rated voltage and frequency, it shall operate to connect the loads to the generator set by opening the normal source contacts, and closing the alternate source contacts a predetermined time period later. The timing sequence for the contact operation shall be programmable in the controller.
- 2.14.3.5 The generator set shall operate connected to the load for the duration of the exercise period. If the generator set fails during this period, the transfer switch shall automatically reconnect the generator set to the normal service.
- 2.14.3.6 On completion of the exercise period, the transfer switch shall operate to connect the loads to the normal source by opening the alternate source contacts, and closing the normal source contacts a predetermined time period later. The timing sequence for the contact operation shall be programmable in the controller.
- 2.14.3.7 The transfer switch shall operate the generator set unloaded for a cool-down period, and then remove the start signal from the generator set. If the normal power fails at any time when the generator set is running, the transfer switch shall immediately connect the system loads to the generator set.
- 2.14.4 Generator Set Exercise (Test) Without Load Mode. The control system shall be configurable to test the generator set without transfer switch load connected. In this mode, the transfer switch shall control the generator set in the following sequence:
 - 2.14.4.1 Transfer switch shall initiate the exercise sequence at a time indicated in the exercise timer program, or when manually initiated by the operator.
 - 2.14.4.2 When the control systems senses the generator set at rated voltage and frequency, it shall operate the generator set unloaded for the duration of the exercise period.
 - 2.14.4.3 At the completion of the exercise period, the transfer switch shall remove the start signal from the generator set. If the normal power fails at any time when the generator set is running, the transfer switch shall immediately connect the system loads to the generator set.

2.15 SOURCE QUALITY CONTROL

- 2.15.1 The transfer switch manufacturer shall perform a complete operational test on the transfer switch prior to shipping from the factory. Tests shall be conducted as per CSA standards. A certified test report shall be included in each copy of the Operations Manual. Test process shall include calibration of voltage sensors. The following factory tests shall be performed:
 - 2.15.1.1 Visual inspection to verify that each ATS is in accordance with the specifications.
 - 2.15.1.2 Mechanical test to verify that ATS sections are free of mechanical hindrances.
 - 2.15.1.3 Insulation resistance test to ensure integrity and continuity of entire system.
 - 2.15.1.4 Main switch contact resistance test.
 - 2.15.1.5 Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.
- 2.15.2 Provide for the Owner and Consultant to witness factory testing.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Verify existing conditions, including restrictions for moving equipment into position and ensure equipment can suit these limitations.
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- 3.1.2 Coordinate disassembly and field assembly of equipment with the manufacturer.

3.2 INSTALLATION

- 3.2.1 Install transfer switches to in accordance with codes, as shown on the drawings, and as recommended by manufacturer's instructions.
- 3.2.2 Emergency Lighting at Life Safety Transfer Switches
 - 3.2.2.1 Provide Emergency Battery Units in rooms containing Life Safety automatic transfer switches in accordance with Section 26 52 13.13. Units require sufficient capacity to provide 2 hours duration in accordance with CSA C282:19 clause 6.11.1.
 - 3.2.2.2 Minimum illumination: 50 lx (5 fc).
 - 3.2.2.3 Battery units shall include automatic self-diagnostic circuitry, and a transient voltage surge suppressor on the supply site of power to the unit.
- 3.2.3 Provide engraved plastic nameplates.
- 3.2.4 Locate, install and connect transfer equipment as indicated.
- 3.2.5 Check relays and solid state monitors and adjust as required to ensure correct operation.
- 3.2.6 Install and connect remote alarms and IP based monitoring.
 - 3.2.6.1 For Life Safety transfer switches, provide signal cabling to connect "Automatic transfer switch in bypass mode" to Fire Alarm System per Section 28 46 13 to provide remove visual and audible indication per CSA C282:19 clause 9.5.2.
- 3.2.7 Connect generator control wiring.
 - 1.1.1.1 Provide one pair of stranded conductors from the ATS "start-stop" signal contacts to the generator.
 - 1.1.1.2 Provide one-pair of conductors from the ATS "on generator source" contacts to the load bank shunt trip breaker.
- 3.2.8 Set field-adjustable intervals and delays, relays, and engine exerciser. Verify exact set points with the Consultant.

3.3 MANUFACTURER'S FIELD SERVICES

- 3.3.1 The manufacturer shall provide disassembly, field assembly, and field certification services to suit restrictions of moving equipment into place.
- 3.3.2 A factory-authorized service representative is to perform start-up and testing of the ATS in the presence of the commissioning authority.

3.4 FIELD QUALITY CONTROL

- 3.4.1 Perform tests in accordance with Section 26 05 00, and Section 26 08 00.
- 3.4.2 Energize transfer equipment from normal power supply.
- 3.4.3 Set selector switch in "Test" position to ensure proper standby start, running, transfer, retransfer. Return selector switch to "Auto" position to ensure standby shuts down.
- 3.4.4 Set selector switch in "Manual" position and check to ensure proper performance.
- 3.4.5 Set selector switch in "Engine start" position and check to ensure proper performance. Return switch to "Auto" to stop engine.
- 3.4.6 Set selector switch in "Auto" position and open normal power supply disconnect. Standby should start, come up to rated voltage and frequency, and then load should transfer to standby. Allow to operate for 10 minutes, then close main power supply disconnect. Load should transfer back to normal power supply and standby should shutdown. Repeat, at 1 hour intervals, 4 times, complete test with selector switch in each position, for each test.

3.5 SITE TESTS AND INSPECTIONS

- 3.5.1 Submit commissioning reports to the Consultant.
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- 3.5.2 A factory-authorized service representative is required to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
- 3.5.3 Following completion of automatic transfer switch installation and after making proper adjustments and settings, site tests shall be performed by the manufacturer's representative in accordance with manufacturer's written instructions to demonstrate that each automatic transfer switch functions satisfactorily and as specified. Advise the Consultant of the site testing within five days prior to its scheduled date, and provide certified field test reports within 14 days following successful completion of the site tests. Test reports shall describe adjustments and settings made and site tests performed. Minimum operational tests shall include the following:
 - 3.5.3.1 Insulation resistance shall be tested, both phase-to-phase and phase-to-ground.
 - 3.5.3.2 Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - 3.5.3.3 Verify that manual transfer warnings are properly placed.
 - 3.5.3.4 Perform manual transfer operation.
 - 3.5.3.5 After energizing circuits, demonstrate the interlocking sequence and operational function.
 - 3.5.3.6 Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - 3.5.3.7 Simulate loss of phase-to-ground voltage for each phase of normal source.
- 3.5.4 Verify time-delay settings.
- 3.5.5 Verify pickup and dropout voltages by data readout or inspection of control settings.
- 3.5.6 Verify proper sequence and correct timing of automatic engine starting, transfer time delay, re-transfer time delay on restoration of normal power, and engine cool-down and shut-down.
- 3.5.7 Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
- 3.5.8 Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.
- 3.5.9 Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.
- 3.5.10 Low phase-to-ground voltage shall be simulated for each phase of normal source.
- 3.5.11 Operation and settings shall be verified for specified automatic transfer switch operational feature, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.
- 3.5.12 Manual and automatic transfer and bypass isolation functions shall be verified.

3.6 CLEANING

- 3.6.1 Progress Cleaning: clean in accordance with Section 01 74 19. Leave Work area clean at end of each day.
- 3.6.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools, and equipment in accordance with Section 01 74 19.

3.7 DEMONSTRATION

- 3.7.1 At the final inspection in the presence of the Consultant, demonstrate that the complete auxiliary electrical power system operates properly in every respect.
 - 3.7.2 Coordinate this demonstration with the demonstration of the engine-generator.
 - 3.7.3 Demonstrate operation of transfer switch in bypass, normal, and emergency modes.
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- 3.7.4 Demonstrate operation of IP based monitoring and configuration.

3.8 TRAINING

- 3.8.1 The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided.
- 3.8.2 The training program shall be not less than two hours in duration.
- 3.8.3 Training date shall be coordinated with the Owner.

END OF SECTION

1 GENERAL

1.1 SUMMARY

1.1.1 Section Includes

- 1.1.1.1 These specifications describe pertinent material requirements and installation practices for externally mounted, Low Voltage AC Power Panel Surge Protective Devices (SPDs). Furnish and install the SPDs equipment having the electrical characteristics, ratings and modifications as specified herein and as shown on the contract drawings.
- 1.1.1.2 The specifications in this section describe the electrical and mechanical requirements for a protection system provided by high-energy Surge Protective Devices. The specified system shall provide effective, high-energy surge current diversion and be suitable for application in ANSI/IEEE C62.41 Category A, B, and C environments (as tested by ANSI/IEEE C62).

1.1.2 Applicability

- 1.1.2.1 SPDs shall be fully applicable for the purpose of protecting all facility AC electrical circuits from the hazardous effects of transient voltages. These transients may be generated externally by lightning induced energies, utility load factor corrections, and substation switching, or they can be internally generated due to inductive and/or capacitive load switching.

1.1.3 Suitability

- 1.1.3.1 SPDs shall be suitable for all service entrance switchboards, panelboards and motor control centres as indicated on the electrical layouts and single line diagrams. Products are to be configured for parallel installation - no series designs shall be considered acceptable. Design products to allow installation as a stand-alone device allowing mounting adjacent to switchboards, panelboards, and motor control centres. Installation is to be accomplished by a qualified electrical contractor.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 24 13 – Switchboards.
- 1.2.2 Section 26 24 16 – Panelboards.
- 1.2.3 Section 26 28 16.02 – Molded Case Circuit Breakers.

1.3 REFERENCES

1.3.1 CSA Group:

- 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
- 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.3.1.3 CSA C22.2 No. 269.2-17 – Surge Protective Devices - Type 2 - Permanently Connected.

1.3.2 Institute of Electrical and Electronics Engineers (IEEE):

- 1.3.2.1 IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
 - 1.3.2.2 IEEE C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.
 - 1.3.2.3 IEEE C62.45-2002, Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.
 - 1.3.2.4 IEEE C62.62-2010, Standard Test Specifications for Surge Protective Devices.
 - 1.3.2.5 IEEE 142-2007, Recommended Practice for Grounding of Industrial and Commercial Power Systems - Green Book.
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- 1.3.2.6 IEEE 1100-2005, Recommended Practice for Powering and Grounding Electronic Equipment - Emerald Book.
- 1.3.3 National Electrical Manufacturers Association (NEMA):
 - 1.3.3.1 NEMA LS-1. Document rescinded in entirety August 19, 2009. No replacement document has been issued.
- 1.3.4 Ontario Building Code and its referenced standards.
- 1.3.5 Underwriters Laboratories Inc. (UL):
 - 1.3.5.1 ANSI/UL 1449, (4th Edition), Standard for Safety, Surge Protective Devices.
 - 1.3.5.2 UL 1283 (4th Edition) - 2005, Standard for Electromagnetic Interference Filters.
- 1.3.6 Other relevant standards:
 - 1.3.6.1 MIL-STD-220C, Method of Insertion-Loss Measurement.

1.4 DEFINITIONS

- 1.4.1 Surge Protective Device: A device composed of at least one non-linear component and intended for limiting surge voltages on equipment by diverting or limiting surge current and is capable of repeating these functions as specified. SPDs were previously known as Transient Voltage Surge Suppressors (TVSS) or secondary surge arresters.
- 1.4.2 SPD Types:
 - 1.4.2.1 Type 1 – Permanently connected device installed before or after the service disconnect overcurrent device and intended to be installed with no external overcurrent protective device.
 - 1.4.2.2 Type 2 – Permanently connected Type 2 SPDs are intended for installation on the load side of the service equipment overcurrent device, including SPDs located at the branch panel.
 - 1.4.2.3 Type 3 – Point of use SPDs that are installed with a minimum of 30 feet of conductor length from the service panel. These 30 feet of conductor length does not include conductors used to attach the SPD. Some examples of Type 3 SPDs are cord connected, direct plug-in and receptacle type SPDs.
 - 1.4.2.4 Type 4 – component assemblies.
 - 1.4.2.5 Type 5 – components.
- 1.4.3 L-G: measurements from phase to equipment grounding conductor as line terminals of utilization equipment.
- 1.4.4 L-L: measurements from phase to phase in a polyphase system, or from one line to another line in a single-phase system.
- 1.4.5 L-N: measurement from phase(s) to neutral for both single and three phase systems.
- 1.4.6 N-G: measurements from neutral to equipment grounding conductor at line terminal of utilization equipment.
- 1.4.7 Externally mounted SPD: Surge Protective Device (SPD) mounted outside of the power panel as a separate component.

1.5 SUBMITTALS

- 1.5.1 Submit in accordance with Section 01 33 00.
 - 1.5.2 Shop Drawings:
 - 1.5.2.1 Line drawings or catalog sheets detailing dimensions and weight of enclosure, lifting and support points, and enclosure details.
 - 1.5.2.2 Internal wiring diagram illustrating all modes of protection in each type of SPD required.
 - 1.5.2.3 Wiring diagram showing all field connections and manufacturer's recommended wire size, recommended circuit breaker or fuse size, required overcurrent protection type, and maximum lead length.
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- 1.5.3 Provide the following product data:
 - 1.5.3.1 Voltage Protection Ratings (VPRs), I-nominal ratings, Short Circuit Current Ratings, SPD type designations, dimensions showing construction, per mode and per phase peak surge current, modes of discrete suppression circuitry, warranty period, and replacement terms.
 - 1.5.3.2 List and detail all protection systems such as fuses, disconnecting means, and protective features.
 - 1.5.4 Submit product data for all components and accessories.
 - 1.5.5 Manufacturer's Installation Instructions:
 - 1.5.5.1 Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.
 - 1.5.5.2 Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
 - 1.5.6 Test reports:
 - 1.5.6.1 Submit cover sheet of test report from a recognized independent testing laboratory certifying compliance with CSA C22.2 No. 269.2.
 - 1.5.6.2 Provide verification that the SPD complies with CSA C22.2 No. 269.2.
 - 1.5.6.3 Provide spectrum analysis of each unit based on MIL-STD-220C test procedures between 10 kHz and 100 kHz verifying the devices noise attenuation equals or exceeds values indicated in this section.
 - 1.5.6.4 Documentation verifying Short Circuit Current Rating (SCCR).
 - 1.5.6.5 Proof of UL 1283 listing for EMI filters.
 - 1.5.7 Upon request, present unencapsulated but complete SPD for visual inspection; proprietary technology included. MOV type and quantity shall reflect kA ratings on cut sheets, verification of monitoring, thermal, overcurrent protection, etc.
 - 1.5.8 Include the following information:
 - 1.5.8.1 Data for each suppressor type indicating conductor sizes, conductor types, and connection configuration and lead lengths.
 - 1.5.8.2 Manufacturer's certified test data indicating the ability of the product to meet or exceed requirements of this specification.
 - 1.5.8.3 Drawings, with dimensions, indicating SPD mounting arrangement and lead length configuration, and mounting arrangement of any optional remote diagnostic equipment and assemblies.
 - 1.5.8.4 List and detail all protection systems such as fuses, disconnecting means and protective materials.
 - 1.5.8.5 Indicate SPD wiring, bonding, and grounding connections on wiring diagrams for each system. Include installation details demonstrating mechanical and electrical connections to equipment to be protected.
 - 1.5.8.6 Wiring diagram of SPD diagnostic indicators.
 - 1.6 **CLOSEOUT SUBMITTALS**
 - 1.6.1 Maintenance data: submit operation and maintenance data, and engineering data for incorporation into manual specified in Section 01 77 00.
 - 1.6.2 Warranty document.
 - 1.7 **ENVIRONMENTAL REQUIREMENTS**
 - 1.7.1 Operating temperature range: -40 degrees C to 70 degrees C (-40 degrees F to 160 degrees F).
 - 1.7.2 Elevation: Operation up to 3 658 m (12 000 feet) above sea level.
 - 1.7.3 Generate no appreciable magnetic fields.
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1.8 DELIVERY, STORAGE, AND HANDLING

- 1.8.1 Deliver, store, and handle in accordance with Section 01 60 00.
- 1.8.2 Store materials in dry, secure location and protect from weather.
- 1.8.3 Protect from moisture and humidity.
- 1.8.4 Store in accordance with manufacturer's written instructions.
- 1.8.5 Waste management and disposal in accordance with Section 01 74 19.

1.9 MANUFACTURER WARRANTY

- 1.9.1 Five-year warranty.
- 1.9.2 Since "Acts of Nature" or similar statements typically include the threat of lightning to which the SPD shall be exposed, any such clause limiting warranty responsibility in the general conditions of this specification shall not apply to this section. This is, the warranty shall cover the effects of lightning, single phasing, and all other electrical anomalies. The warranty shall cover the entire device, not just various components, such as modules only.

1.10 MANUFACTURER QUALIFICATIONS

- 1.10.1 Manufacturer regularly engaged in the design, manufacturing and testing of SPD's of the types and ratings required for a period of not less than five years. Manufacturers requesting product approval must meet or exceed the written specification contained herein. Manufacturers requesting approval must receive written verification of product acceptance by the Consultant ten days prior to the bid date.

1.11 QUALITY ASSURANCE

- 1.11.1 All SPDs manufactured by a single ISO 9001 registered company normally engaged in the design, development, and manufacture of such devices for electrical and electronic system equipment protection.
- 1.11.2 Manufacturer regularly engaged in the manufacture of surge suppression products for the specified categories for minimum of ten years.
- 1.11.3 Manufacturer shall offer repair or replacement service for all materials and components incorporated in the Surge Protective Devices.
- 1.11.4 Technical assistance (no cost to customer) provided by manufacturer through a factory representative or a local distributor and a factory staffed toll-free technical hotline.
- 1.11.5 Manufacturer shall provide a toll-free customer service phone number to facilitate all inquiries regarding product returns, warranty claims, purchasing requirements and payment or credit issues.
- 1.11.6 Listed to most recent edition of CSA C22.2 No. 269.2.
- 1.11.7 Products certified by a recognized testing agency accredited by the Standards Council of Canada, and bear a certification mark from that agency indicating acceptance to Canadian standards.
 - 1.11.7.1 Equipment certification by one of the following bodies:
 - (1) Listed by Underwriters Laboratories, Inc. and exhibit the cUL Listing Mark for the category "Surge Protective Devices" or SPD. Provide UL Listing Card under category VZCA7 (SPDs certified for Canada) to confirm compliance to CSA C22.2 No. 269.2, and assigned Voltage Protection Ratings.
 - (2) Listed by ETL.
 - (3) Certified by CSA Group.

- 1.11.7.2 SPD to be labeled with no less than a 100 kA Short Circuit Current Rating (SCCR).

2 PRODUCTS

2.1 OUTDATED AND DEFUNCT SPECIFICATION CRITERIA

- 2.1.1 Selection of SPD is not be made, solely, or in part, based upon any of the following ambiguous specifications, and obsolete terminology. These terms are no longer recognized by ANSI, NEMA, IEEE, or IEC standards as bonafide suppressor performance parameters. Submittals bearing reference to any of the following will be rejected.
- 2.1.1.1 A1 ringwave: removed in 2002 revisions of IEEE C62 documents.
 - 2.1.1.2 Joule ratings: there is no recognized standard for SPD joule ratings.
 - 2.1.1.3 NEMA LS-1: document rescinded by NEMA.
 - 2.1.1.4 Response time: not endorsed by IEEE, NEMA, or UL as a valid SPD rating parameter.
 - 2.1.1.5 Suppressed Voltage Ratings (SVR): terminology deprecated with UL 1449 third and subsequent editions.

2.2 MANUFACTURERS

- 2.2.1 Manufacturer List
- 2.2.1.1 Asco.
 - 2.2.1.2 Citel.
 - 2.2.1.3 Current Technology.
 - 2.2.1.4 Mersen.
 - 2.2.1.5 Raycap Electrical Protection Systems.
 - 2.2.1.6 Total Protection Solutions.
- 2.2.2 Substitution Limitations: No unit will be accepted as an “approved equal” unless it meets the warranty, strength, safety features, performance ratings, and all other requirements of this specification.
- 2.2.3 Product Options:
- 2.2.3.1 The inclusion of a manufacturer in the following list does not indicate the manufacturer meets all the requirements in this specification. Likewise, the omission of a manufacturer is not indicative of any lack of qualification. The manufacturer and product must meet all the requirements of this specification.
 - 2.2.3.2 The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety. Products in compliance with the specification and manufactured by others not named will be considered only if pre-approved by the Consultant ten (10) days prior to bid date.

2.3 SURGE PROTECTION DEVICES – GENERAL

- 2.3.1 Obtain all surge suppression devices through one source from a single manufacturer.
 - 2.3.2 SPD separate from panelboards. Integral SPDs not acceptable.
 - 2.3.3 The SPD listed by recognized testing agency accredited by the Standards Council of Canada, and bear a certification mark from that agency indicating acceptance to Canadian standards, and to UL’s 1283 and UL’s 1449 standards (latest edition, latest revision), and not merely the components or modules. Label all SPDs as a Type 2 for use in Type 1 and Type 2 locations.
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- 2.3.4 Protect all modes L-G, L-N, L-L, and N-G, have discrete suppression circuitry in L-G, L-N, and N-G, and have bidirectional, positive, and negative impulse protection. Line-to-neutral-to-ground protection is not acceptable where line-to-ground is specified, and accordingly reduced mode units with suppression circuitry built into only four modes are not acceptable. In delta systems, line-to-ground-to-line protection is not acceptable where line-to-line is specified.
- 2.3.5 If a disconnect switch is specified, the disconnect switch and the SPD as a system shall be capable of interrupting up to a minimum 100 kA symmetrical fault current with 600 VAC applied.
- 2.3.6 Suppression Components:
- 2.3.6.1 Metal Oxide Varistors (MOVs).
- 2.3.6.2 Gas tubes, silicon avalanche diodes, or selenium cells: not permitted.
- 2.3.6.3 Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls, such as through the use of Thermally Protected MOVs (TPMOVs).
- 2.3.6.4 Where SPD is not equipped with overtemperature controls, pack all surge components, current carrying paths and fusing in fuse grade silica sand or epoxy potting for arc quenching capability, minimization of smoke and contaminants in the event of failure.
- 2.3.7 Internal Fusing - Overcurrent Protection
- 2.3.7.1 Individually fuse each suppression component for safety and performance.
- 2.3.7.2 Fusing shall be present in every mode, including Neutral-to-Ground.
- 2.3.7.3 All overcurrent protection must be included within the device, and not require external overcurrent protection.
- 2.3.8 Surge Current Rating
- 2.3.8.1 Service Entrance: 200 kA per phase.
- 2.3.8.2 Distribution: 100 kA to 200 kA per phase.
- 2.3.8.3 Point of Use: 100 kA per phase.
- 2.3.9 Short Circuit Current Rating (SCCR), sometimes referred to as fault current rating: minimum 100 kA.
- 2.3.10 Nominal Discharge Current (I_n , or I_{nominal}):
- 2.3.10.1 UL labelled with a minimum 10 kA I_{nominal} .
- 2.3.11 Maximum Continuous Operating Voltage (MCOV): The maximum continuous operating voltage (MCOV) of all components not less than 125 per cent for a 120 V system, 120 per cent for 220 V and 240 V systems, and 115 per cent for 347 V and 600 V systems.
- 2.3.11.1 277 V systems: 320 V MCOV.
- 2.3.11.2 480 V systems: 552 V MCOV.
- 2.3.12 Voltage Protection Ratings (VPRs) to not exceed the following:

<u>Voltage</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>
208Y/120	800 V	800 V	800 V
480Y/277	1200 V	1200 V	1200 V
600Y/347	1500 V	1500 V	1500 V
<u>Voltage</u>	<u>L-L</u>	<u>L-G</u>	
480 Delta	1800 V	1800 V	
600 Delta	2500 V	2500 V	

- 2.3.13 Minimum EMI/RFI filtering of -50 dB at 100 kHz.
- 2.3.14 SPD enclosure:
- 2.3.14.1 Minimum NEMA type 12 rating in indoor applications.
- 2.3.14.2 Minimum NEMA type 4 in outdoor applications.

- 2.3.15 Diagnostics and Monitoring:
 - 2.3.15.1 Visual LED diagnostics to indicate failure of a suppression component. Monitor every suppression component of every mode, including N-G.
 - 2.3.15.2 Form C dry contacts (NO or NC) for remote monitoring capability to indicate the failure of any MOV in the unit.
 - 2.3.15.3 Surge event counter with backup power source.

2.4 SERVICE ENTRANCE AND TRANSFER SWITCH SPDS

- 2.4.1 CSA certified and labeled as a Type 2 device.
- 2.4.2 SPDs relying on an external breaker or fuse as supplemental overcurrent protection do not meet the intent of this specification and will be rejected.
- 2.4.3 CSA certified listed and labeled with a minimum I-nominal rating of 20 kA.
- 2.4.4 An approved disconnect switch provided as a means of service disconnect if a 60 A breaker is not available.
- 2.4.5 Connect SPD using the manufacturer's breaker/wire recommendations. If recommendations are not available, use a 60 amp breaker and 6 AWG cable with full size ground.
- 2.4.6 Minimum Surge Current Rating: 200 kA per phase (100 kA per mode).

2.5 DISTRIBUTION PANELBOARD AND MOTOR CONTROL CENTRE SPDS

- 2.5.1 CSA certified listed and labeled as a Type 2 device.
- 2.5.2 SPDs relying on an external breaker or fuse as supplemental overcurrent protection do not meet the intent of this specification and will be rejected.
- 2.5.3 CSA certified listed and labeled with a minimum I-nominal rating of 20 kA.
- 2.5.4 SPD connected using the manufacturer's breaker/wire recommendations. If recommendations are not available a 60 A breaker and 6 AWG with full size ground will be used.
- 2.5.5 Minimum Surge Current Rating: 100 kA per phase (50 kA per mode).

2.6 LIGHTING AND RECEPTACLE BRANCH CIRCUIT PANELBOARD SPDS

- 2.6.1 CSA certified listed and labeled as a Type 2 device.
- 2.6.2 SPDs relying on an external breaker or fuse as supplemental overcurrent protection do not meet the intent of this specification and will be rejected.
- 2.6.3 CSA certified listed and labeled with a minimum I-nominal rating of 10 kA.
- 2.6.4 SPD connected using the manufacturer's breaker/wire recommendations. If recommendations are not available a 60 A breaker and 6 AWG will be used.
- 2.6.5 Minimum Surge Current Rating: 100 kA per phase (50 kA per mode).

3 EXECUTION

3.1 PRE-INSTALLATION MEETINGS

- 3.1.1 Pre-installation meetings: conduct pre-installation meeting one week prior to commencing work of this Section and on-site installations to verify project requirements, substrate conditions and co-ordination with other building sub-trades, to review manufacturer's installation instructions and warranty requirements.
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3.2 FIELD QUALITY CONTROL

- 3.2.1 Have manufacturer of products supplied under this Section review Work involved in the handling, installation, application, protection, and cleaning of its products. Submit written reports in acceptable format to verify compliance of Work with Contract in accordance with Section 01 33 00 and Section 01 77 00.
- 3.2.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
- 3.2.3 Schedule site visits to review work at stages listed:
 - 3.2.3.1 After delivery and storage of products, and when preparatory work on which the work of this Section depends is complete, but before installation begins.
 - 3.2.3.2 Twice during progress of work at 66 per cent and 99 per cent complete.
 - 3.2.3.3 Upon completion of the work, after cleaning is carried out.
- 3.2.4 Obtain reports within three (3) days of review and submit immediately to the Consultant.

3.3 EXAMINATION

- 3.3.1 Verify service and separately derived system Neutral to Ground bonding jumpers.

3.4 INSTALLATION

- 3.4.1 Do complete installation in accordance with CSA C22.1, CSA C22.2 No. 0, ANSI/IEEE C62.41, and all other applicable codes.
 - 3.4.2 Manufacturer's instructions:
 - 3.4.2.1 Install SPD in accordance with manufacturer's installation instructions with lead lengths as short and as straight as practically possible. Lead lengths no greater than 600 mm (24 inches). Gently twist conductors together.
 - 3.4.2.2 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage, and installation instructions.
 - 3.4.3 Connect SPD to service panel being protected via a circuit breaker for each phase, based on the number of poles and the connecting wire size, with a 100 A maximum.
 - 3.4.4 Follow the SPD manufacturer's recommended installation practice as outlined in the equipment installation manual. Ensure that all neutral conductors are bonded to the system ground at the service entrance or the serving isolation transformer prior to installation of the associated SPD.
 - 3.4.5 Installation position of SPD:
 - 3.4.5.1 Locate SPD adjacent to the panelboard, in a position as close as possible to the neutral and ground lugs. Rearrange breaker positions for SPDs to minimize the length of the phase, neutral, and ground conductors.
 - 3.4.5.2 Mount SPD as close as possible to panel being protected in a position that will minimize lead lengths between suppressor and control breaker(s) to which suppressor connects. Utilize conduit, preferably metallic, to accomplish these connections with a recommended minimum wire size of 10 AWG, a maximum wire size of 4 AWG (for ease of dressing), or as noted on the single line diagram. Do not extend suppressor leads beyond manufacturer's recommended maximum length without specific engineering approval. The rationale for this is the longer connecting leads between the SPD and the power panel, the higher the residual transient voltage.
 - 3.4.5.3 Locate surge suppressors as indicated and mount securely, plumb, true, and square to adjoining surfaces.
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- 3.4.5.4 Install surface mounted surge suppressors on fire-retardant plywood backboards as recommended in manufacturer's written instructions. Where practical, group SPDs on common backboard with other equipment.
- 3.4.5.5 Mount housings and enclosures on fire-retardant plywood backboard with top not higher than 1.8 m (6 feet) above finished floor.
- 3.4.6 Wiring:
 - 3.4.6.1 Install units on a breaker, sized, where indicated, that meets or exceeds the fault current rating of the switchgear or panelboard.
 - 3.4.6.2 Connect SPD to service panel being protected via a circuit breaker for each phase, based on the number of poles and the connecting wire size. Connect SPD using the manufacturer's breaker/wire recommendations.
 - (1) If recommendations are not available, a 60 A breaker and 6 AWG phase, neutral, and ground conductors will be used.
 - (2) If the SPD is supplied with lead wires, match the overcurrent protection to the 75 degree C ampacity of the wiring as described in Ontario Electrical Safety Code, Table 2; i.e. a 30 A breaker to suit 10 AWG lead wires.
 - 3.4.6.3 Install SPD in a neat, workmanlike manner. Dress leads as short and as straight as possible and be consistent with recommended industry practices for the application on which these units are installed. Bind phase, neutral, and ground conductors tightly (one twist per 30 cm) over entire run, from suppressor to service panel, and always use the shortest length of connecting cable possible.
 - 3.4.6.4 If the SPD is supplied by the manufacturer with lead wires, cut excess lead length.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Solid state, light emitting diode (LED) source interior luminaires.
- 1.1.2 New, fully integrated luminaires for indoor applications.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 09 43 – Network Lighting Controls.
- 1.2.2 Section 26 52 13.13 – Emergency Lighting.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 250.0 - Luminaires (Bi-National Standard, with UL 1598).
- 1.3.2 DesignLights Consortium (DLC):
 - 1.3.2.1 Solid-State Lighting Technical Requirements v5.1, or latest edition.
 - 1.3.2.2 Where the specifications do not explicitly call for DLC qualified LED luminaires, the technical criteria provided in the DLC Technical Requirements provide the basis of the requirements for this section of the Specification.
- 1.3.3 Energy Star:
 - 1.3.3.1 Program Requirements for Luminaires - Eligibility Criteria, Version 1.2, or latest edition.
- 1.3.4 Illuminating Engineering Society (IES):
 - 1.3.4.1 IES HB-10-11 – The Lighting Handbook, 10th Edition.
 - 1.3.4.2 IES Im-79-08 – Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products.
 - 1.3.4.3 IES Im-80-08 – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
 - 1.3.4.4 IES TM-21-11 – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
- 1.3.5 IEEE 1789-2015 – IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.
- 1.3.6 National Electrical Manufacturer's Association (NEMA):
 - 1.3.6.1 SSL-1-10 – Electronic Drivers for LED Devices, Arrays, or Systems.
 - 1.3.6.2 WD 6 - Wiring Devices - Dimensional Requirements.

1.4 DEFINITIONS

- 1.4.1 CCT: Correlated colour temperature.
- 1.4.2 CRI: Colour-rendering index.
- 1.4.3 LED: Light Emitting Diode.
- 1.4.4 Lumen: Measured output of lamp and luminaire, or both.
- 1.4.5 Luminaire: Complete lighting fixture, including ballast housing if provided.

1.5 ACTION SUBMITTALS

- 1.5.1 Refer to Section 01 33 00.
 - 1.5.2 Manufacturer reports: Provide a point-by-point photometric analysis of the facility, in accordance with the procedures laid out in IES recommended practices to demonstrate
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compliance with OBC illumination requirements as described in 2012 OBC 3.11.10.1.(3)(a)(i). and with basis of design illumination requirements.

- 1.5.3 Product submittals shall be accompanied by product specification sheets or other documentation that includes the designed parameters as detailed in this specification. These parameters include (but not limited to):

1.5.3.1 Maximum power in Watts.

- (1) If a transformer is used in conjunction with a driver (for example on some 347 V lighting circuits), the maximum power shall include the transformer losses.

1.5.3.2 L70 in hours, when extrapolated for the worse case operating temperature. TM-21 report shall be submitted to demonstrate this.

1.5.3.3 Product submittals shall be accompanied by performance data that is derived in accordance with appropriate IESNA testing standards and tested in a laboratory that is NVLAP accredited for Energy Efficient Lighting Products.

1.6 INFORMATIONAL SUBMITTALS

- 1.6.1 Installation instructions.

1.7 CLOSEOUT SUBMITTALS

- 1.7.1 Section 01 77 00: Submittals for project closeout.
1.7.2 Submit manufacturer's operation and maintenance instructions for each product.
1.7.3 Warranty information.

1.8 QUALIFICATIONS

- 1.8.1 Manufacturer: Company specializing in manufacturing the products specified in this section with minimum five years documented experience.

1.9 REGULATORY REQUIREMENTS

- 1.9.1 Products shall be listed and classified by CSA (Canadian Standards Association), ULC (Underwriter's Laboratories of Canada), or certified by recognized independent testing organizations that test to CSA standards.
1.9.2 Products shall be certified by a recognized testing agency accredited by the Standards Council of Canada and bear a certification mark from that agency.
1.9.3 All luminaires shall be listed and labeled for installation in fireproof or non-fireproof construction, dry, damp, or wet locations as required.
1.9.4 Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.

1.10 DELIVERY, STORAGE, AND HANDLING

- 1.10.1 Deliver, store and handle materials in accordance with Section 01 60 00.
1.10.2 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.

1.11 EXTRA STOCK MATERIALS

- 1.11.1 Refer to Section 01 77 00.
1.11.2 Provide the following additional equipment as listed herein.
1.11.2.1 Provide an additional 2 per cent spare luminaires of each new type to be provided.
1.11.2.2 Provide 1 per cent of each plastic lens type.
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- 1.11.2.3 Provide three of each type of any special tools required for system use and maintenance.

1.12 WARRANTY

- 1.12.1 Refer to Section 01 77 00 and Section 26 05 00.
- 1.12.2 The manufacturer shall provide a warranty against loss of performance and defects in materials and workmanship for the luminaires for a period of 5 years after acceptance of the luminaires. Warranty shall cover all components comprising the luminaire.
- 1.12.3 All warranty documentation shall be provided to customer prior to the first shipment.
- 1.12.4 LED Luminaires shall have a manufacturer's warranty for a period of not less than five years.
- 1.12.5 LED boards, drivers and associated components shall have a warranty of 5 years on the LEDs, 5 years on the driver, 10 years on the paint finish.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 As noted on Lighting Fixture Schedule.
- 2.1.2 Approved equal.

2.2 INDOOR LED LUMINAIRES, GENERAL

- 2.2.1 Initial delivered lumens – thermal losses should be less than 10 per cent when operated at a steady state at an average ambient operating temperature of 25 degrees C, and optical losses should be less than 15 per cent.
- 2.2.2 Average Delivered Lumens – Average delivered lumens over 50 000 hours should be minimum of 85 per cent of initial delivered lumens.
- 2.2.3 All luminaires shall be tested per lm79/80 and published L70 data.
- 2.2.4 Available in 3500 K correlated colour temperature, CRI greater than or equal to 80, or as indicated.
- 2.2.5 Accessibility and Maintenance:
 - 2.2.5.1 All LED luminaires shall be field serviceable, with LED arrays, LED modules, drivers, etc. fully serviceable and easily accessible. In the case of recessed ceiling mounted, and in the case of surface mounted ceiling fixtures, these components must be accessible from below. Luminaires in which any of these components are accessible only from above are not acceptable.
 - 2.2.5.2 Ballasts, drivers, LED arrays, LED modules, and lamps shall be serviceable while the fixture is in its normally installed position. Ballasts or drivers shall not be mounted to removable reflectors or wireway covers unless so specified. In the case of ceiling mounted luminaires, the serviceable components must be accessible from below.
- 2.2.6 Housings:
 - 2.2.6.1 Formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.
 - 2.2.6.2 Sheet steel housings to be minimum 20 gauge.
 - 2.2.6.3 Wireways and fittings: free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
 - 2.2.6.4 When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.

- 2.2.6.5 Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.
- 2.2.6.6 Drivers shall not be mounted to removable reflectors or wireway covers unless so specified.
- 2.2.7 Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- 2.2.8 Metal Finishes:
 - 2.2.8.1 Fixture finish and construction to meet ULC listings and CSA certifications related to intended installation.
 - 2.2.8.2 All metal components of fixtures shall be painted after fabrication to mitigate raw metal edges, and thus prevent premature corrosion.
 - 2.2.8.3 The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.
 - 2.2.8.4 Interior light reflecting finishes shall be white with not less than 85 per cent reflectance, except where otherwise shown on the drawing.
- 2.2.9 Wiring:
 - 2.2.9.1 Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.
 - 2.2.9.2 Supplied complete with a luminaire disconnect plug.
- 2.2.10 Flicker control:
 - 2.2.10.1 All electric lights (except decorative lights, emergency lights and other special-purpose lighting) used in regularly occupied spaces meet at least one of the following requirements for flicker:
 - (1) A minimum frequency of 90 Hz at all 10% intervals from 10% to 100% light output.
 - (2) LED products with a "low risk" level of flicker (light modulation) of less than 5%, especially below 90 Hz operation as defined by IEEE standard 1789-2015 LED.

2.3 DRIVERS, GENERAL

- 2.3.1 Electronic LED drivers shall be integral to the luminaire, and be designed to be accessible in the field for replacement and servicing.
 - 2.3.2 Input Voltage:
 - 2.3.2.1 Driver with a voltage range of (120-277) $\pm 10\%$ or (347-480) $\pm 10\%$.
 - 2.3.2.2 Refer to lighting fixture schedule.
 - 2.3.2.3 For luminaires connected to a 347 V circuit and utilizing a natively 120-277 V driver, provide an appropriately sized step down transformer.
 - 2.3.3 Input frequency 60 Hz.
 - 2.3.4 Load regulation: ± 1 per cent from no load to full load.
 - 2.3.5 Output ripple less than 10 per cent.
 - 2.3.6 Output should be isolated.
 - 2.3.7 Case temperature: rated for -40°C through $+80^{\circ}\text{C}$.
 - 2.3.8 Overheat protection, self-limited short circuit protection and overload protected.
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- 2.3.9 Primary fused.
- 2.3.10 Driver life rating not less than 50 000 hours
- 2.3.11 Power Factor and Total Harmonic Distortion
 - 2.3.11.1 Power factor of greater than or equal to 0.9 at full load.
 - 2.3.11.2 THD of less than or equal to 20 per cent at full load.
- 2.3.12 Dimming Control:
 - 2.3.12.1 Coordinate with Section 26 09 43.
 - 2.3.12.2 0-10 V dimming control typical for all fixtures unless otherwise noted.
 - 2.3.12.3 Control range: 10 per cent to 100 per cent typical, unless noted otherwise.
 - 2.3.12.4 Provide a mock-up to demonstrate the luminaire is free of flicker throughout the dimming range when used with the dimming controllers described in related sections.

2.4 INTERIOR WALL-WASH LED LUMINAIRES

- 2.4.1 Minimum Light Output: 575 lm.
- 2.4.2 Zonal lumen density:
 - 2.4.2.1 Minimum 60 per cent between 0 degrees and 90 degrees from nadir.
 - 2.4.2.2 Minimum 60 per cent of the lumens must be produced in the "forward" hemisphere, towards the wall.
- 2.4.3 Minimum luminaire efficacy: 45 lm/W.
- 2.4.4 Correlated Colour Temperature (CCT): 3500 K.
- 2.4.5 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.4.6 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with lm-80 testing data and TM-21 extrapolation.

2.5 TRACK OR MONO-POINT DIRECTIONAL LED LUMINAIRES

- 2.5.1 Minimum Light Output: 250 lm.
- 2.5.2 Zonal lumen density:
 - 2.5.2.1 Minimum 85 per cent between 0 degrees and 90 degrees from nadir.
- 2.5.3 Minimum luminaire efficacy: 45 lumens per watt.
- 2.5.4 Correlated Colour Temperature (CCT): 3500 K.
- 2.5.5 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.5.6 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with lm-80 testing data and TM-21 extrapolation.

2.6 DOWNLIGHT LUMINAIRES

- 2.6.1 Minimum Light Output: 500 lm.
- 2.6.2 Zonal lumen density: Minimum 75 per cent between 0 degrees and 60 degrees from nadir.
- 2.6.3 Minimum luminaire efficacy: 45 lumens per watt.
- 2.6.4 Correlated Colour Temperature (CCT): 3500 K.
- 2.6.5 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.6.6 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with lm-80 testing data and TM-21 extrapolation.

2.7 NOMINAL 610 MM BY 610 MM (2 FOOT BY 2 FOOT) LUMINAIRES FOR AMBIENT LIGHTING OF INTERIOR SPACES

- 2.7.1 Minimum Light Output: 2 000 lm.
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- 2.7.2 Zonal lumen density:
 - 2.7.2.1 Minimum 75 per cent between 0 degrees and 60 degrees from nadir.
- 2.7.3 Spacing Criteria:
 - 2.7.3.1 0 degrees to 180 degrees: 1.0 to 2.0.
 - 2.7.3.2 90 degrees to 270 degrees: 1.0 to 2.0.
- 2.7.4 Minimum luminaire efficacy: 85 lumens per watt.
- 2.7.5 Correlated Colour Temperature (CCT): 3500 K.
- 2.7.6 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.7.7 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.8 *NOMINAL 305 MM BY 1220 MM (1 FOOT BY 4 FOOT) LUMINAIRES FOR AMBIENT LIGHTING OF INTERIOR SPACES*

- 2.8.1 Minimum Light Output: 1 500 lm.
- 2.8.2 Zonal lumen density:
 - 2.8.2.1 Minimum 75 per cent between 0 degrees and 60 degrees from nadir.
- 2.8.3 Spacing Criteria:
 - 2.8.3.1 0 degrees to 180 degrees: 1.0 – 2.0.
 - 2.8.3.2 90 degrees to 270 degrees: 1.0 – 2.0.
- 2.8.4 Minimum luminaire efficacy: 85 lumens per watt.
- 2.8.5 Correlated Colour Temperature (CCT): 3500 K.
- 2.8.6 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.8.7 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.9 *NOMINAL 610 MM BY 1220 MM (2 FOOT BY 4 FOOT) LUMINAIRES FOR AMBIENT LIGHTING OF INTERIOR SPACES*

- 2.9.1 Minimum Light Output: 3 000 lm.
- 2.9.2 Zonal lumen density:
 - 2.9.2.1 Minimum 75 per cent between 0 degrees and 60 degrees from nadir.
- 2.9.3 Spacing Criteria:
 - 2.9.3.1 0 degrees to 180 degrees: 1.0 – 2.0.
 - 2.9.3.2 90 degrees to 270 degrees: 1.0 – 2.0.
- 2.9.4 Minimum luminaire efficacy: 85 lumens per watt.
- 2.9.5 Correlated Colour Temperature (CCT): 3500 K.
- 2.9.6 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.9.7 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.10 *LINEAR AMBIENT LUMINAIRES: INDIRECT*

- 2.10.1 Minimum Light Output: 500 lm per foot.
 - 2.10.2 Zonal lumen density:
 - 2.10.2.1 Minimum 50 per cent between 90 degrees and 150 degrees from nadir.
 - 2.10.3 Minimum luminaire efficacy: 85 lumens per watt.
 - 2.10.4 Correlated Colour Temperature (CCT): 3500 K.
 - 2.10.5 Colour Rendition Index (CRI): 80 CRI minimum.
 - 2.10.6 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.
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2.11 LINEAR AMBIENT LUMINAIRES: INDIRECT/DIRECT

- 2.11.1 Minimum Light Output: 500 lm per foot.
- 2.11.2 Zonal lumen density:
 - 2.11.2.1 Minimum 25 per cent between 0 degrees and 60 degrees from nadir.
 - 2.11.2.2 Minimum 50 per cent between 90 degrees and 150 degrees from nadir.
- 2.11.3 Minimum luminaire efficacy: 85 lumens per watt.
- 2.11.4 Correlated Colour Temperature (CCT): 3500 K.
- 2.11.5 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.11.6 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.12 LINEAR AMBIENT LUMINAIRES: DIRECT/INDIRECT

- 2.12.1 Minimum Light Output: 500 lm per foot.
- 2.12.2 Zonal lumen density:
 - 2.12.2.1 Minimum 40 per cent between 0 degrees and 60 degrees from nadir.
 - 2.12.2.2 Minimum 35 per cent between 90 degrees and 150 degrees from nadir.
- 2.12.3 Minimum luminaire efficacy: 85 lumens per watt.
- 2.12.4 Correlated Colour Temperature (CCT): 3500 K.
- 2.12.5 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.12.6 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.13 LINEAR AMBIENT LUMINAIRES: DIRECT

- 2.13.1 Minimum Light Output: 375 lm per foot.
- 2.13.2 Zonal lumen density:
 - 2.13.2.1 Minimum 40 per cent between 0 degrees and 60 degrees from nadir.
- 2.13.3 Minimum luminaire efficacy: 85 lumens per watt.
- 2.13.4 Correlated Colour Temperature (CCT): 3500 K
- 2.13.5 Colour Rendition Index (CRI): 80 CRI minimum.
- 2.13.6 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.14 HIGH-BAY LUMINAIRES FOR COMMERCIAL AND INDUSTRIAL BUILDINGS

- 2.14.1 Minimum Light Output: 10 000 lm.
- 2.14.2 Zonal lumen density:
 - 2.14.2.1 Minimum 30 per cent between 20 degrees and 50 degrees from nadir.
- 2.14.3 Minimum luminaire efficacy: 80 lumens per watt.
- 2.14.4 Correlated Colour Temperature (CCT): 4000 K
- 2.14.5 Colour Rendition Index (CRI): 70 CRI minimum.
- 2.14.6 Minimum L70 lumen maintenance to occur at 35 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.15 LOW-BAY LUMINAIRES FOR COMMERCIAL AND INDUSTRIAL BUILDINGS

- 2.15.1 Minimum Light Output: 5 000 lm.
 - 2.15.2 Zonal lumen density:
 - 2.15.2.1 Minimum 30 per cent between 20 degrees and 50 degrees from nadir.
 - 2.15.3 Minimum luminaire efficacy: 80 lumens per watt.
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- 2.15.4 Correlated Colour Temperature (CCT): 4000 K
- 2.15.5 Colour Rendition Index (CRI): 70 CRI minimum.
- 2.15.6 Minimum L70 lumen maintenance to occur at 35 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

2.16 HIGH-BAY AISLE LUMINAIRES

- 2.16.1 Minimum Light Output: 10 000 lm.
- 2.16.2 Zonal lumen density:
 - 2.16.2.1 Minimum 30 per cent between 0 degrees and 20 degrees from nadir.
 - 2.16.2.2 Minimum 50 per cent between 20 degrees and 50 degrees from nadir.
- 2.16.3 Minimum luminaire efficacy: 80 lumens per watt.
- 2.16.4 Correlated Colour Temperature (CCT): 4000 K
- 2.16.5 Colour Rendition Index (CRI): 70 CRI minimum.
- 2.16.6 Minimum L70 lumen maintenance to occur at 35 000 hours in accordance with Im-80 testing data and TM-21 extrapolation.

3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

- 3.1.1 Coordinate the lighting system installation with the relevant trades so as to eliminate interferences with hangers, mechanical ducts, sprinklers, piping, steel, etc.

3.2 INSTALLATION

- 3.2.1 Install lighting equipment, including but not limited to luminaires, controls, auxiliary devices, and the integration of same in strict conformance with all manufacturers' recommendations and instructions the securing of which shall be the responsibility of the Contractor.
- 3.2.2 Integrate luminaires with controls in accordance with respective luminaire manufacturers' and controls manufacturers' recommendations and instructions and to provide a complete, trouble-free operation without compromising safety, code and CSA requirements.
- 3.2.3 Seal all luminaires for wet locations (i.e. all knock-outs, all pipe and wire entrances, etc.) as is standard industry practice to prevent water from entering luminaires.
- 3.2.4 Luminaire Alignment:
 - 3.2.4.1 Locate recessed ceiling luminaires as indicated on reflected ceiling plan. Install recessed luminaires to permit removal from below. Include accessories and materials to meet applicable codes and regulatory requirements.
 - 3.2.4.2 Align luminaires mounted in continuous rows to form straight uninterrupted line.
 - 3.2.4.3 Align luminaires mounted individually parallel or perpendicular to building grid lines.
 - 3.2.4.4 Install surface mounted luminaires plumb and adjust to align with building lines and with each other. Secure to prevent movement.
 - 3.2.4.5 Locate and install luminaires as indicated. Mounting heights and configuration of the luminaires shall be as specified in the Luminaire Schedule portion of the Specification or indicated on the drawings, and where conflicts exist, as approved by the Consultant.
 - 3.2.4.6 Installed all luminaires plumb and true and level as viewed from all directions unless specifically identified otherwise in the Lighting Fixture Schedule. Luminaires shall remain plumb and true without continual adjustment or visibly obvious means beyond what is shown on luminaire submittal drawings.

- 3.2.4.7 For installation in suspended ceilings, ensure that the luminaires are supported such that there is no resultant bowing or deflection of the ceiling system greater than 1/360 of the length of the total span of the ceiling member.
- 3.2.5 Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.
- 3.2.6 Whenever a luminaire or its hanger canopy is installed directly to a surface mounted junction box, use a finishing ring painted to match the ceiling to conceal the junction box.
- 3.2.7 Suspended Luminaires:
 - 3.2.7.1 Install suspended luminaires and exit signs using pendants supported from swivel hangers. Provide pendant length required to suspend luminaire at indicated height.
 - 3.2.7.2 Suspended luminaires shall be installed plumb and true and level unless specifically identified otherwise in the Luminaire Schedule portion of this Specification and at a height from finished floor as specified on the drawings, details and Luminaire Schedule. In cases where this is impractical, refer to the Consultant for a decision. All appurtenances shall be consistently organized for a neat, uniform appearance.
- 3.2.8 Install wall mounted luminaires at height as indicated.
- 3.2.9 Accessories:
 - 3.2.9.1 Reflector cones, louvers, baffles, lenses, trims, and other decorative elements shall be installed after completion of ceiling tile installation, plastering, painting and general cleanup.
 - 3.2.9.2 Install accessories provided with each luminaire.
 - 3.2.9.3 All accessories shall be properly installed and adjusted by Contractor in accordance with specification and installation instructions. Any spare items shall be clearly labeled (indicate type of accessory and associated luminaire types).

3.3 TESTING AND ADJUSTMENT

- 3.3.1 As required, all adjustable luminaires shall be aimed, focused, locked, etc., by the Contractor under the observation of the Consultant. As aiming and adjusting is completed, locking setscrews and bolts and nuts shall be tightened securely by the Contractor.
- 3.3.2 For luminaires with field selectable lumen output and/or CCT, ensure the correct setting matches the intended set points.
- 3.3.3 All ladders, scaffolds, lifts, etc. required for aiming and adjusting luminaires shall be furnished by the Contractor.
- 3.3.4 Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing lighting effects, aiming shall be accomplished at night.

3.4 LUMINAIRE SUPPORTS

- 3.4.1 Provide adequate support to suit ceiling system.
 - 3.4.2 Support luminaires independently of ceiling framing, unless ceiling is certified by the manufacturer to support weight of installed devices. Confirm if T-bar ceilings are metric or imperial and provide luminaires to suit ceiling dimensions.
 - 3.4.3 Provide chain hangers for new and existing luminaires.
 - 3.4.4 Install clips to secure recessed grid-supported luminaires in place.
 - 3.4.5 Fixtures supported by suspended ceiling systems shall be securely fastened to the ceiling framing member by mechanical means, such as bolts, screws, or rivets. Ceiling framing members must be securely attached to each other and to the building structure as required by all applicable codes and standards. Use of integral clips is not acceptable.
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3.5 WIRING

- 3.5.1 Use SPC90 conductors for final connections to luminaires (including 0-10 V dimming conductors for applicable luminaires).
- 3.5.2 Install luminaire disconnect plugs on all new luminaires not provided as such from the manufacturer.
- 3.5.3 Connect luminaires to branch circuit outlets provided under Section 26 05 33.13 using flexible conduit.
- 3.5.4 Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.
- 3.5.5 Bond products and metal accessories to branch circuit equipment grounding conductor.

3.6 FIELD QUALITY CONTROL

- 3.6.1 Operate each luminaire after installation and connection. Inspect for proper connection and operation.
- 3.6.2 Make wiring connections to the branch circuit using building wire with insulation suitable for temperature conditions within luminaire.
- 3.6.3 Occupancy Sensors.
 - 3.6.3.1 Locate and aim sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas.
 - 3.6.3.2 Rooms shall have 90 per cent to 100 per cent coverage to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room.
 - 3.6.3.3 Exercise proper judgment in executing the work to ensure the best possible installation in the available space and to overcome local difficulties due to space limitations or interference of structural components.

3.7 CLEANING

- 3.7.1 Thoroughly clean all luminaires and accessories after installation. All fingerprints, dirt, tar, smudges, drywall mud, dust, etc. shall be removed by the Contractor from the luminaire bodies, reflectors, trims, and lens or louvers prior to final acceptance. All reflectors shall be free of paint other than factory-applied, if any. All reflectors, cones and lenses shall be cleaned only according to manufacturers' instructions.
- 3.7.2 Clean electrical parts to remove conductive and deleterious materials.
- 3.7.3 Remove dirt and debris from enclosures.
- 3.7.4 Clean photometric control surfaces as recommended by manufacturer.
- 3.7.5 Clean finishes and touch up damage.
- 3.7.6 Luminaire finishes which are disturbed in any way during construction shall be touched up or refinished in a manner satisfactory to the Consultant.

3.8 COMMISSIONING

- 3.8.1 In accordance with Section 26 08 50.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Emergency lighting units with battery back-up for emergency illumination of remote emergency fixtures and internally illuminated exit signs.
- 1.1.2 Remote emergency fixtures.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 51 19 – LED Interior Lighting.
- 1.2.2 Section 26 52 13.16 – Exit Signs.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.2 No. 141-15 (R2020), Emergency lighting equipment.
 - 1.3.1.2 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.3 Ontario Electrical Safety Code (28th edition/2021).
- 1.3.2 Ontario Building Code.
- 1.3.3 National Building Code of Canada.
- 1.3.4 Underwriters Laboratories, Inc. (UL):
 - 1.3.4.1 UL 924 – Standard for Safety of Emergency Lighting and Power Equipment.

1.4 SUBMITTALS

- 1.4.1 Submit in accordance with Section 01 33 00.
- 1.4.2 Product Data:
 - 1.4.2.1 Submit manufacturer's instructions, printed product literature and data sheets for emergency lighting and include product characteristics, performance criteria, physical size, finish, and limitations.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Submit in accordance with Section 01 77 00.
- 1.5.2 Operation and Maintenance Data: submit operation and maintenance data for emergency lighting for incorporation into manual.

1.6 EXTRA MATERIALS

- 1.6.1 Allow the cost for material and for installation of the following to be installed as directed by the Consultant during construction:
 - 1.6.1.1 An additional five single head emergency remote units.
 - 1.6.1.2 An additional five dual head emergency remote units.
 - 1.6.1.3 An additional one battery unit, based on the maximum battery capacity as specified.

1.7 QUALITY ASSURANCE

- 1.7.1 Manufacturer Qualifications: Products shall be free of defects in material and workmanship.
 - 1.7.2 Furnished products are listed and/or certified by third party agencies as suitable for the intended purpose.
 - 1.7.3 All units will be certified that they have been tested prior to shipping.
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1.8 DELIVERY, STORAGE, AND HANDLING

- 1.8.1 Deliver, store, and handle materials in accordance with Section 01 60 00 and with manufacturer's written instructions.
- 1.8.2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.
- 1.8.3 Storage and Handling Requirements:
 - 1.8.3.1 Store materials off ground indoors in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - 1.8.3.2 Store and protect emergency lighting from nicks, scratches, and blemishes.
 - 1.8.3.3 Replace defective or damaged materials with new.
- 1.8.4 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding and packaging materials as specified in Construction Waste Management Plan in accordance with Section 01 74 19.

1.9 WARRANTY

- 1.9.1 Product is warranted free of defects in material and workmanship.
- 1.9.2 Product is warranted to perform the intended function within design limits.
- 1.9.3 For batteries in this Section, 12 month warranty period is extended to 24 months.

2 PRODUCTS

2.1 EMERGENCY BATTERY UNITS

- 2.1.1 Manufacturers:
 - 2.1.1.1 Lumacell RG12S series.
 - 2.1.1.2 Aimlite.
 - 2.1.1.3 Beghelli.
 - 2.1.1.4 Emergi-Lite.
 - 2.1.1.5 Lithonia (Acuity Brands Lighting).
 - 2.1.1.6 Stanpro.
- 2.1.2 Battery Unit Features:
 - 2.1.2.1 Self-contained unit equipment for LED emergency lighting shall be manufactured and labeled as certified to meet CSA C22.2 No. 141.
 - 2.1.2.2 Housing: Constructed of formed and welded 18 gauge cold rolled steel with knockouts for conduit, finished in baked white enamel. Cabinet suitable for direct or shelf mounting to wall. Removable or hinged front panel for easy access to batteries.
 - 2.1.2.3 Charger:
 - (1) Solid-state micro-controller PCB, Pulse-Guard charger, features include; auto-equalized, temperature compensated, current limited, short circuit and reverse polarity protected.
 - (2) Recharges battery within 24 hours in accordance with CSA requirements.
 - 2.1.2.4 Transfer: Upon failure of the power supply, or voltage dip below 75 per cent of nominal, a sealed relay automatically and instantaneously connects the battery to the emergency lighting load and disconnects when battery discharge reaches 87.5 per cent expectancy.
 - 2.1.2.5 Batteries: seal lead calcium, maintenance free, and 10 year pro-rated service life.
 - 2.1.2.6 Auto-test: Unit to perform self-test for 1 minute ever 30 days, 10 minutes on the 6th month and 30 minutes ever 12 months.

- 2.1.3 Battery Electrical Features:
 - 2.1.3.1 Input Voltage: 120-347 VAC universal input:
 - (1) Provided with plug and receptacle when connected to 120 volt source panelboard.
 - (2) direct connected to 347 volt source panelboard.
 - 2.1.3.2 Output Voltage: 12 VDC; balance loads to battery unit terminals.
 - (1) Normally "Off" output: wattage capacity as indicated for emergency remotes and internally illuminated exit signs.
 - (2) Battery Run Time at full load: must meet OBC minimum, 120 minutes.
 - (3) Voltage regulation: ± 5 per cent of nominal maximum.
 - 2.1.3.3 Signal lights: solid state, for 'AC Power ON' and 'High Charge'.
- 2.1.4 Lamp heads:
 - 2.1.4.1 Integral on unit, 345 degrees horizontal and 180 degrees vertical adjustment.
 - 2.1.4.2 Lamp type:
 - (1) Two 12 V, 6 W MR16 LED lamps mounted on top of the battery cabinet, shall be injection molded thermoplastic, white finish.
 - (2) Average lamp lumens: 170 lm.
 - (3) Centre Beam Candlepower: 440 cd.
 - (4) Beam angle: 30 degrees.
 - (5) Lamp efficacy: 42.5 lm/W.
- 2.1.5 Auxiliary equipment:
 - 2.1.5.1 Ammeter.
 - 2.1.5.2 Voltmeter.
 - 2.1.5.3 Test switch.
 - 2.1.5.4 Time delay relay.
 - 2.1.5.5 Battery disconnect device.
 - 2.1.5.6 AC input and DC output terminal blocks inside cabinet.
 - 2.1.5.7 Shelf Bracket.
 - 2.1.5.8 Cord and single twist-lock plug connection for AC.
 - 2.1.5.9 RFI suppressors.
 - 2.1.5.10 Voltage Sensing Relay:
 - (1) Up to six inputs for line voltage detection from different normal lighting zone. The wire connection from each zone circuit shall be made with terminal blocks.
 - (2) Operation Sequence: In the case of power failure of one or several circuits feeding normal lighting, the output circuit will open and transfer the battery unit(s) in emergency lighting mode.
 - (3) Provide "push to test" push button and a pilot light for each zone circuit for manual testing and service.

2.2 VOLTAGE SENSING RELAY (VSR) ZONE CONTROL STAND-ALONE EXTENSION MODULE

- 2.2.1 Manufacturers: Lumacell VSR series (basis of design).
 - 2.2.2 The equipment shall have an adequate quantity of inputs (up to 24 inputs) for line voltage detection from different building zones. The wire connection from each zone circuit shall be made with terminal blocks. The output circuit shall be a dry-contact relay, normally closed and shall be accessible for connection on a terminal block. The output circuit shall
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be connected at installation in series with the AC line supplying the battery unit equipment.

- 2.2.3 Operation Sequence: In the case of power failure of one or several circuits feeding normal lighting, the output circuit will open and transfer the battery unit(s) in emergency lighting mode.
- 2.2.4 Include a "push to test" push button and a pilot light for each zone circuit for manual testing and service.

2.3 EMERGENCY LIGHTING EMERGENCY REMOTE HEADS

- 2.3.1 Refer to drawings and lighting schedule.
- 2.3.2 One or two lamps, shall be injection molded thermoplastic, white finish, lamps shall be MR16 LED 12 V, 540 lumen, 25 degree beam angle, 6 watt.
- 2.3.3 Remote heads to be mounted not less than 2100 mm (6'-10") AFF.
- 2.3.4 LED MR16 lamps:
 - 2.3.4.1 Lumacell MQM-x-12V4W-LD10 series.
 - 2.3.4.2 Approved equal by Emergi-Lite.
 - 2.3.4.3 Approved equal by Stanpro.
 - 2.3.4.4 Approved equal by Beghelli.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections are acceptable for emergency lighting installation in accordance with manufacturer's written instructions.
 - 3.1.1.1 Visually inspect substrate in presence of Owner.
 - 3.1.1.2 Inform Owner of unacceptable conditions immediately upon discovery.
 - 3.1.1.3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Owner.

3.2 INSTALLATION

- 3.2.1 Install emergency lighting in compliance with local inspection authorities.
- 3.2.2 Wiring:
 - 3.2.2.1 Connect battery input to source panelboard. Balance the emergency lighting loads connected to battery output terminal blocks. Provide and connect remote fixtures and internally illuminated exit signs as specified and as required for system performance in compliance with OBC minimum egress illumination requirements. Install remotes in locations as shown on the drawings. Connect all remotes to normally "Off" output from battery units.
 - 3.2.2.2 Contractor is responsible for revisions to system, including relocations, aiming and additional remote heads as determined by testing results. All wiring shall be in accordance with manufacturer's recommendations.
 - 3.2.2.3 Use minimum #10 gauge or heavier if needed to provide a maximum voltage drop of 5 per cent. Consult manufacturer's table for sizing the minimum gage and length of wire runs permitted for connected loads to ensure a maximum voltage drop of 5 per cent from the battery unit to the farthest emergency remote, in accordance with OBC and local inspection authorities.
- 3.2.3 Mounting: Suitable for wall mounting, complete with bracket from manufacturer lighting heads, test switch and diagnostic LED indicator shall be visible.
- 3.2.4 Provide Voltage Sensing Relays internal or external to battery units to meet the intent of OESC Rule 46-304 (4). Unit equipment shall be installed in such a manner that it will be

automatically actuated upon failure of the power supply to the normal lighting in the area covered by that unit equipment.

3.3 TESTING AND COMMISSIONING

- 3.3.1 When installation of emergency lighting equipment is complete, contractor shall commission and test the entire system and adjust if necessary.
- 3.3.2 Contractor is responsible for arranging and cost of a verification test of emergency illumination levels by the manufacturer's representative.
 - 3.3.2.1 Verification test shall be performed with a lux/footcandle meter at 1 m intervals along all paths of egress throughout the space, and record light level readings on floor plans provided by the consultant.
 - 3.3.2.2 The contractor shall also provide consultant with a letter stating the recorded emergency lighting levels meet the OBC requirements of 10 lx (1 fc) average with minimum readings not less than 1 lx (0.1 fc) on the path of egress.
 - 3.3.2.3 The manufacturer is to provide a letter of verification confirming testing and operation of all emergency lighting as well as installation to all applicable codes.
- 3.3.3 Contractor is to indicate in the letter the duration of emergency lighting run time that was observed.
- 3.3.4 Testing shall be performed during non-daylight hours. Contractor shall aim all remotes to optimise illumination on the floor and stair.
- 3.3.5 Contractor shall certify in writing to the consultant that the system is complete, installed per CSA C22.2 No. 141, has been tested, and operates for the specified battery run time.
- 3.3.6 Contractor shall notify Owner and consultant at least ten days prior to proposed testing date and schedule testing at time and date acceptable to the Owner.
- 3.3.7 Installation shall be in accordance to the electrical code and manufacturer's instructions.
- 3.3.8 The Contractor is to submit a letter on Contractor's letterhead confirming the criteria specified above is met, including light levels, and run time, and include a copy of the plans with light levels recorded.
- 3.3.9 Provide breaker lock on emergency lighting circuit at source panelboard.

3.4 PROTECTION

- 3.4.1 Protect installed products and components from damage during construction.
- 3.4.2 Repair damage to adjacent materials caused by emergency lighting installation.

3.5 TESTING, MAINTENANCE, AND WARRANTY SERVICE

- 3.5.1 Provide complete instructions for the operation and care of the emergency power supply or unit equipment that shall specify testing at least once every month to ensure security of operation. Instructions to be framed under glass.
- 3.5.2 OBC testing obligations: Owner's facility maintenance personnel are required to document one manual test of the battery units each month, and conduct one full discharge test once a year per OBC and CSA C22.2 No.141 requirements.
- 3.5.3 Annual Maintenance: The manufacturer recommends maintenance to be performed by a qualified service provider. Contact the manufacturer for any warranty service.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Internally illuminated "Running Man" exit sign units for ordinary location use.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 52 13.13 – Emergency Lighting: Emergency Battery Units.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 141-15 (R2020), Emergency lighting equipment.
 - 1.3.1.4 CAN/CSA-C860-11 (R2020), Performance of Internally Lighted Exit Signs.
- 1.3.2 International Organization for Standardization (ISO):
 - 1.3.2.1 ISO 7010:2011 – Graphical symbols – Safety colours and safety signs.
 - 1.3.2.2 ISO 3864-1:2011 – Graphical symbols -- Safety colours and safety signs -- Part 1: Design principles for safety signs and safety markings
- 1.3.3 Ontario Building Code.
- 1.3.4 Underwriters Laboratories of Canada (ULC):
 - 1.3.4.1 ULC/ORD-924-02, Standard for Emergency Lighting and Power Equipment.
 - 1.3.4.2 CAN/ULC-S572-10, First Edition Standard for Photoluminescent and Self-Luminous Exit Signs and Path Marking Systems.

1.4 SUBMITTALS

- 1.4.1 Provide submittals in accordance with Section 01 33 00.
- 1.4.2 Product Data: Submit manufacturer's printed product literature, specifications and datasheet and include product characteristics, performance criteria, physical size, finish, and limitations.
- 1.4.3 Instructions: submit manufacturer's installation instructions and special handling criteria, installation sequence, cleaning procedures and maintenance.

1.5 EXTRA MATERIALS

- 1.5.1 Allow the cost for material and for installation of an additional five exit signs, single face or dual face, to be installed as directed by the Consultant during construction. Include 15.24 m (50 feet) of wire and conduit per exit sign.

1.6 QUALITY ASSURANCE

- 1.6.1 Exit signs units shall be ULC Listed and/or CSA Certified to CSA C22.2 No. 141 and CSA C860.
- 1.6.2 Furnished products are listed and/or certified by third party agencies as suitable for the intended purpose.
- 1.6.3 Manufacturer Qualifications: Products shall be free of defects in material and workmanship.
- 1.6.4 All units will be certified that they have been tested prior to shipping.

1.7 DELIVERY, STORAGE, AND HANDLING

- 1.7.1 In accordance with Section 01 60 00.
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1.8 WASTE MANAGEMENT AND DISPOSAL

- 1.8.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 19.

1.9 WARRANTY

- 1.9.1 Product is warranted free of defects in material and workmanship for a minimum of one year from substantial completion.

2 PRODUCTS

2.1 EXIT SIGNS, GENERAL

- 2.1.1 Manufacturers
- 2.1.1.1 Airlite.
 - 2.1.1.2 Beghelli.
 - 2.1.1.3 Emergi-Lite.
 - 2.1.1.4 Lithonia (Acuity Brands Lighting).
 - 2.1.1.5 Lumacell.
 - 2.1.1.6 Stanpro.
 - 2.1.1.7 Other manufacturers as indicated in Section 26 52 13.13.
- 2.1.2 Substitution Limitations:
- 2.1.2.1 Manufacturer of exit signs to be the same as manufacturer of emergency lighting battery units and remote heads specified in Section 26 52 13.13.
 - 2.1.2.2 No manufacturer substitutions.
- 2.1.3 Description
- 2.1.3.1 Green and White LED Pictogram "Running Man" exit sign.
 - 2.1.3.2 The pictogram sign shall be certified as CSA 22.2 No. 141, and meet ISO 3864-1 and ISO 7010.
 - 2.1.3.3 The pictogram legend shall have a minimum illuminated dimension of 5.9" high and 11.13" with ISO 3864-1 and ISO 7010 pictogram printed on a pure-acrylic panel.
 - 2.1.3.4 The sign shall include a standard single face with optional double-faceplate included.
 - 2.1.3.5 Not acceptable:
 - (1) Red LED EXIT signs.
 - (2) Externally illuminated photoluminescent, or non-electrical radioluminescent type of pictogram signs are unacceptable.
- 2.1.4 Mounting
- 2.1.4.1 The canopy shall universal to allow for wall, end, or ceiling mount.
- 2.1.5 Electrical
- 2.1.5.1 The LED light source shall be long-life white Light-Emitting Diodes and shall provide uniform illumination of the pictogram in normal and emergency operation.
 - 2.1.5.2 The sign shall operate with universal 2-wire AC input voltage of 120 to 347 Vac at less than 3 Watts, and universal 2-wire DC input voltage from 6 to 24 Vdc at less than 2.5 Watts for single and double face legends with a single arrow either left or right.
 - 2.1.5.3 If arrow left and arrow right is required for T intersection, the contractor shall supply and install two separate pictogram signs.
 - 2.1.5.4 The pictogram edge-lit exit sign where indicated on the plans in a self-powered configuration shall use a sealed Nickel-Cadmium battery of 2.4 V nominal
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voltage and shall stay illuminated during emergency operation for at least two hours upon AC failure.

2.2 ALL-PLASTIC PICTOGRAM EXIT SIGN, COMMERCIAL GRADE

2.2.1 Manufacturers

2.2.1.1 Lumacell LP Series

2.2.1.2 Equivalent products from manufacturers as described in Article 2.01 of this section.

2.2.2 Materials

2.2.2.1 The sign shall come standard with a canopy and shall be suitable for wall, end, or ceiling mounting. The frame, faceplates, back plate and canopy shall each be constructed of a one-piece UV-stabilized thermoplastic material colored factory white.

2.3 ALL-CLIMATE, HARSH ENVIRONMENT PICTOGRAM EXIT SIGN

2.3.1 Manufacturers

2.3.1.1 Lumacell LN Series

2.3.1.2 Equivalent products from manufacturers as described in Article 2.01 of this section.

2.3.2 Materials

2.3.2.1 The equipment shall be certified for NEMA-4X and designed specifically for high abuse areas, wet location, and cold weather applications.

2.3.2.2 The equipment frame shall be of industrial grade polyvinyl chloride with a gasket around lenses and canopy. The faceplate(s) shall be constructed of heavy-duty vandal resistant polycarbonate and feature an even illuminated legend.

2.3.2.3 Finish colour: white.

3 EXECUTION

3.1 INSTALLATION

3.1.1 Install exit lights to manufacturer's recommendations, listing requirements, CSA standard and local regulatory requirements.

3.1.2 Ensure exit signs are not obscured. Where an exit sign is to be installed in an area with no ceiling, provide a suitable pendant mount.

3.1.3 Connect fixtures to exit light circuits normal power supply and emergency battery units specified in Section 26 52 13.13.

3.1.4 Ensure that emergency lighting circuit breaker is locked in ON position.

3.1.5 If arrow left and arrow right is required for T intersection, the contractor shall supply and install two separate pictogram signs.

3.2 FIELD QUALITY CONTROL

3.2.1 Comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.3 CLEANING

3.3.1 Proceed in accordance with Section 01 74 19.

3.3.2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

3.4 TESTING AND COMMISSIONING

- 3.4.1 When installation of emergency lighting equipment is complete, contractor shall commission and test the entire system and adjust if necessary.
- 3.4.2 Contractor shall certify in writing to the consultant that the system is complete, installed per CSA C22.2 No. 141, has been tested, and operates for the specified battery run time.
- 3.4.3 Contractor shall notify owner and consultant at least ten days prior to proposed testing date and schedule testing at time and date acceptable to the owner.
- 3.4.4 Installation shall be in accordance to the electrical code and manufacturer's instructions.
- 3.4.5 Provide breaker lock on emergency lighting circuit at source panelboard.

3.5 PROTECTION

- 3.5.1 Protect installed products and components from damage during construction.
- 3.5.2 Repair damage to adjacent materials caused by exit sign installation.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Materials and installation for steel lighting poles.
- 1.1.2 Architectural concrete bases.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 03 30 00 – Cast-in-Place Concrete.
- 1.2.2 Section 26 56 19 – LED Exterior Lighting.
- 1.2.3 Section 31 23 00 – Excavation and Backfill.

1.3 REFERENCES

- 1.3.1 CSA Group
 - 1.3.1.1 CSA C22.2 No. 206-17, Lighting poles.

1.4 COORDINATION

- 1.4.1 Ensure shop drawings are submitted promptly to ensure adequate time for the Consultant's review and to permit timely release of anchor bolts.
- 1.4.2 Coordinate the installation of all light poles with the work of other trades. This includes but is not limited to placement of poles in conjunction with civil work such as sidewalks, roadways, parking lots, landscaping and building exteriors.

1.5 SUBMITTALS

- 1.5.1 Submit product data in accordance with Section 01 33 00.
 - 1.5.2 Product Data: For each pole, accessory, luminaire-supporting and lowering device, arranged as indicated on the plans and as required.
 - 1.5.2.1 Include data on construction details, profiles, effective projected area (EPA), cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
 - 1.5.2.2 Include finishes for lighting poles and luminaire-supporting devices.
 - 1.5.2.3 Anchor bolts.
 - 1.5.2.4 Manufactured pole foundations.
 - 1.5.2.5 Manufacturer cut sheets indicating pole catalog number selections with highlighted selections. Include pole designations that match the project designations if applicable.
 - 1.5.2.6 All distinct poles required on the project shall be submitted in one single submittal so all poles can be reviewed at one time.
 - 1.5.3 Shop Drawings:
 - 1.5.3.1 Anchor-bolt templates keyed to specific poles and certified by manufacturer.
 - 1.5.3.2 Include plans, elevations, sections, and mounting and attachment details.
 - 1.5.3.3 Include details of equipment assemblies, indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1.5.3.4 Detail fabrication and assembly of poles and pole accessories.
 - 1.5.3.5 Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the jurisdiction of the project site.
 - 1.5.3.6 Method and procedure of pole installation. Include manufacturer's written installation instructions.
 - 1.5.4 Delegated Design Submittals:
-

- 1.5.4.1 Soil test report prepared by a Geotechnical Engineer licensed in the jurisdiction of the project site.
- 1.5.4.2 Provide pole base details using the submitted poles and luminaires, sealed by a Structural Engineer licensed in the jurisdiction of the project site.
- 1.5.4.3 Contractor is responsible for hiring geotechnical and structural engineers as part of base bid.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 In accordance with Section 01 77 00.
- 1.6.2 Include soil reports and sealed base details in O&M manual.
- 1.6.3 Reviewed shop drawings.
- 1.6.4 Warranty documentation.

1.7 DELIVERY, STORAGE, AND HANDLING

- 1.7.1 Protect products from moisture and dust by storing them in a clean, dry location remote from areas involved in construction operations. Provide additional protection in accordance with manufacturer's instructions.
- 1.7.2 Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- 1.7.3 Retain factory-applied pole wrappings on metal poles until immediately before pole installation. Handle poles with web fabric straps.
- 1.7.4 Protect pole finishes prior and during install by applying a strippable, temporary protective covering as required.

1.8 WARRANTY

- 1.8.1 Special Warranty: Manufacturer agrees to repair or replace components of pole(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.
 - 1.8.1.1 Warranty Period: Five (5) years from date of Substantial Completion.
 - 1.8.1.2 Warranty Period for Corrosion Resistance: Five (5) years from date of Substantial Completion.
 - 1.8.1.3 Warranty Period for Colour Retention: Five (5) years from date of Substantial Completion.

2 PRODUCTS

2.1 ARCHITECTURAL CONCRETE BASES

- 2.1.1 Manufacturers:
 - 2.1.1.1 Manufacturer list:
 - (1) ArtFORMS International Inc. (basis of design).
Tel: 905 642-3225, Fax: 905-642-3227,
Email: ArtFORMS@ArtFORMSConcreteBases.com.
 - 2.1.1.2 Substitution limitations:
 - (1) Equivalent architectural precast concrete luminaire pole base by Utility Structures Inc. or approved equal.
- 2.1.2 Provide bases in styles, sizes, and profiles indicated. Depth of bases to be in accordance with Structural Engineer's detail.
- 2.1.3 Cast-in-place architectural concrete base (basis of design):

- 2.1.3.1 Use single-use Concrete Forms.
- 2.1.3.2 Provide cast-in-place architectural concrete bases for lighting poles, bollards, floodlights, flagpoles, signs, columns fence posts, and other applications as noted.
- 2.1.3.3 Self-locking, vandal-resistant, wraparound aluminum colour accent band around finished bases, where indicated.

2.2 PAINTED GALVANIZED STEEL POLES

- 2.2.1 Galvanized steel poles: to CSA C22.2 No. 206 designed for underground wiring and:
 - 2.2.1.1 Suitable for mounting on concrete anchor base.
 - 2.2.1.2 Monotube style, minimum 3.0 mm thick, straight or tapered, round or square as indicated.
 - 2.2.1.3 Access handhole 300 mm (12 inches) above pole base for wiring connections, with welded-on reinforcing frame and bolted-on cover.
 - 2.2.1.4 Galvanized anchor bolts complete with galvanized double nuts and galvanized washers, and plastic bolt covers.
 - 2.2.1.5 Two lugs: one for grounding and one for bonding.
 - 2.2.1.6 Two-piece aluminium base cover to suit pole.
 - 2.2.1.7 Manufacturer's standard flat pole cap.
 - 2.2.1.8 Effective Projected Area (EPA) rating to meet or exceed the requirement of luminaires, mounting brackets, etc.
 - 2.2.1.9 Finishes:
 - (1) Polyester powder coat finish.
 - 2.2.1.10 Manufacturer's nameplate indicating manufacturer's name, model number of pole, and date of manufacture with a permanent, stamped/printed or engraved label.
- 2.2.2 Manufacturers:
 - 2.2.2.1 Aluminous Lighting Products.
 - 2.2.2.2 Dynapole.
 - 2.2.2.3 LSI Industries.
 - 2.2.2.4 Lumec.
 - 2.2.2.5 Polefab.
 - 2.2.2.6 Spina.
 - 2.2.2.7 Valmont West Coast Engineering.

2.3 POLE ACCESSORIES

- 2.3.1 Duplex Receptacle: Only where required of particular project scope, a 120 V, 15 A, specification grade receptacle in a weatherproof assembly complying with Section 26 27 26, ground-fault circuit-interrupter type.
 - 2.3.1.1 Surface mounted, a minimum of 300 mm (12 inches) above finished grade, or at the height indicated on the plans.
 - 2.3.1.2 Nonmetallic polycarbonate, weatherproof, while-in-use cover.
 - 2.3.1.3 With cord opening allowing for use while the cover is pad locked.

2.4 LUMINAIRE MOUNTING BRACKETS

- 2.4.1 Mounting brackets for specified luminaires:
 - 2.4.1.1 Single, twin, and quad brackets as indicated.

2.5 LUMINAIRES

- 2.5.1 In accordance with Section 26 56 19.
-

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- 3.1.2 Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.
- 3.1.3 Examine roughing-in for foundation and conduit to verify actual locations of installation.
- 3.1.4 Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BASE INSTALLATION

- 3.2.1 Install specified below-grade fiber form, reinforcing steel, ducts, etc. to required grade.
- 3.2.2 Place form on top of empty fiber form. Position vertical seams in desired direction.
- 3.2.3 Pour specified concrete through open top of form into fiber form below. Avoid contact with inside surface. Bring concrete to top of formwork.
- 3.2.4 Mechanically vibrate concrete with small vibrator, and vigorously hand tap outside surface of formwork.
- 3.2.5 Place and centre anchor bolt assembly (or post, etc.) into concrete. Trowel-finish top surface of concrete.
- 3.2.6 Reinforce bases with vertical steel reinforcing rods and horizontal steel reinforcing ties as noted on the drawings.
- 3.2.7 Coordinate installation of conduit at bases for lighting poles, bollards, floodlights, and signs.
- 3.2.8 Cast and cure bases in accordance with requirements of Section 03 30 00.
- 3.2.9 Install self-locking, vandal-resistant, wraparound aluminum colour accent band around finished bases, where indicated.
- 3.2.10 Base Stripping:
 - 3.2.10.1 Strip concrete form within 24 hours of pouring of base.
 - 3.2.10.2 Cut steel bands. Strip form in two halves. Pry open at the two vertical seams with flat-bladed hand-tool e.g. ice-scraper or square-nose shovel. Insert blade and separate form at top, middle, and bottom of first seam. Repeat for second seam.
 - 3.2.10.3 Wire brush any traces of form material remaining on finished concrete base.
 - 3.2.10.4 Use rubbing stone to make smooth any rough concrete edges around top of base and along vertical seams.
 - 3.2.10.5 If there is risk of damage by construction equipment to exposed base, protect base by tie-wiring or duct taping the two formwork halves back in place around base until safe to remove protection.
 - 3.2.10.6 Install colour accent band(s), where applicable, in horizontal reveal(s) around finished base.

3.3 POLE INSTALLATION

- 3.3.1 Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
 - 3.3.2 Raise and set poles using web fabric slings (not chain or cable) at locations indicated by manufacturer.
 - 3.3.3 Install poles true and plumb, complete with brackets in accordance with manufacturer's instructions.
-

- 3.3.4 Mount standards on bases plumb and true utilizing shims as required and then securely anchor standards to anchor bolts. Touch up all chips and scratches on poles upon completion.
- 3.3.5 Provide label on each pole to allow for individual identification of each pole, minimum 125 mm (5 inch) text height of contrasting colour to that of pole finish, installed at approximately 3048 mm (10 feet) above finished grade.
- 3.3.6 Install luminaires on pole.
- 3.3.7 Check luminaire orientation, level, and tilt.
- 3.3.8 Connect luminaires to lighting circuits.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Pole mounted, wall mounted, and canopy mounted solid state, light emitting diode (LED) source exterior luminaires.

1.2 RELATED REQUIREMENTS

- 1.2.1 Division 04 – Masonry: brick grinding requirements for wall mounted luminaires.
- 1.2.2 Section 25 56 50 – Integrated Automation Control of Electrical Lighting Systems.
- 1.2.3 Section 26 09 43 – Network Lighting Controls.
- 1.2.4 Section 26 56 13 – Lighting Poles and Standards.

1.3 REFERENCES

- 1.3.1 CSA Group:
 - 1.3.1.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.1.2 Ontario Electrical Safety Code (28th edition/2021).
 - 1.3.1.3 CSA C22.2 No. 9.0 – General Requirements for Luminaires.
 - 1.3.1.4 CSA C22.2 No. 250.0 – Luminaires (Bi-National Standard, with UL 1598).
 - 1.3.1.5 CAN/CSA-C22.2 No. 250.13 – Light Emitting Diode (LED) equipment for lighting applications.
- 1.3.2 DesignLights Consortium (DLC):
 - 1.3.2.1 Solid-State Lighting Technical Requirements v5.1, or latest edition.
 - 1.3.2.2 Where the specifications do not explicitly call for DLC qualified LED luminaires, the technical criteria provided in the DLC Technical Requirements provide the basis of the requirements for this section of the Specification.
- 1.3.3 Illuminating Engineering Society (IES)
 - 1.3.3.1 IES HB-10-11 – The Lighting Handbook, 10th Edition.
 - 1.3.3.2 IES LM-79-08 – Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products.
 - 1.3.3.3 IES LM-80-08 – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.
 - 1.3.3.4 IES TM-21-11 – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.
- 1.3.4 National Electrical Manufacturer's Association (NEMA)
 - 1.3.4.1 SSL-1-10 – Electronic Drivers for LED Devices, Arrays, or Systems.
 - 1.3.4.2 WD 6 - Wiring Devices - Dimensional Requirements.
- 1.3.5 Underwriters Laboratories Inc. (UL):
 - 1.3.5.1 ANSI/UL 1449, (4th Edition), Standard for Safety, Surge Protective Devices.

1.4 ACTION SUBMITTALS

- 1.4.1 Submit product data in accordance with Section 01 33 00.
 - 1.4.2 Manufacturer reports: Provide a point-by-point photometric analysis of the site, in accordance with the procedures laid out in IES RP-8-18, for review by the Consultant. Include point-by-point calculation zones along the property line. The designer shall lay out a grid of points on the pavement at a maximum spacing of one-third the light fixture mounting height, commencing within one-half the grid spacing from the perimeter boundary.
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- 1.4.3 Product specification sheets or other documentation that includes the designed parameters as detailed in this specification. These parameters include (but are not limited to):

1.4.3.1 Luminaire cut sheets.

- (1) Highlight all parameters of the complete luminaire part number, including lumen package, correlated colour temperature, IES distribution type, and driver information.
- (2) Highlight the input watts of the luminaire and the B-U-G rating.
- (3) Cut sheet to document L70 lumen maintenance data, in hours, when extrapolated for the worse case operating temperature.

1.5 **INFORMATIONAL SUBMITTALS**

- 1.5.1 Instructions for installation and maintenance.

1.6 **CLOSEOUT SUBMITTALS**

- 1.6.1 Section 01 77 00: Submittals for project closeout.
- 1.6.2 The Contractor shall be responsible for obtaining from the supplying lighting manufacturers, for each luminaire, a recommended maintenance manual including:
- 1.6.2.1 Vendor and local representative's contact information.
 - 1.6.2.2 Tools required.
 - 1.6.2.3 Maintenance instructions.
 - 1.6.2.4 Types of cleaners to be used.
 - 1.6.2.5 Replacement parts identification lists.
 - 1.6.2.6 Equipment product data (high-quality reproducible copies).
- 1.6.3 Complete warranty information including manufacturer's warranty conditions, including driver, luminaire, and accessories.
- 1.6.4 Light level measurements demonstrating the installation is consistent with the photometric analysis.
- 1.6.5 Lighting Manufacturer's photometric analysis when requested by the Consultant during submittal review.

1.7 **QUALITY ASSURANCE**

- 1.7.1 Luminaires tested to IES LM-79.
- 1.7.2 Design Qualification Testing performed by a National Voluntary Laboratory Accreditation Program (NVLAP) testing facility. Such testing may be performed by the manufacturer, or an independent testing lab hired by the manufacturer on new luminaire designs, and when a major design change has been implemented on an existing design. A major design change is defined as a design change (electrical or physical) which changes any of the performance characteristics of the luminaire, results in a different circuit configuration for the power supply, or changes the layout of the individual LED's in the module.
- 1.7.3 Products certified by a recognized testing agency accredited by the Standards Council of Canada, and bearing a certification mark from that agency. Certification shall include wet location rating.

1.8 **WARRANTY**

- 1.8.1 Manufacturer Warranty against loss of performance and defects in materials and workmanship for the luminaires for a period of 5 years after acceptance of the luminaires. Warranty to cover all components comprising the luminaire.
-

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 As noted on Lighting Fixture Schedule.

2.2 OUTDOOR LED LUMINAIRES, GENERAL

- 2.2.1 Maximum nominal luminaire input wattage as specified for each luminaire type as indicated on the Luminaire schedule.
- 2.2.2 Luminaires designed for ease of component replacement and end-of-life disassembly.
- 2.2.3 Input Voltage:
- 2.2.3.1 As indicated on Luminaire schedule.
- 2.2.3.2 Driver to be compatible with system voltage without use of a step-down transformer. If the manufacturer's standard product offering cannot achieve this, clearly indicate on the shop drawings and clearly indicate location of transformer.
- 2.2.4 Surge Protection
- 2.2.4.1 UL 1449 recognized surge protective device that is wired in front of the driver(s) and protects the luminaire to a minimum Category C Low (per ANSI/IEEE C62.41.2).
- 2.2.5 Power Factor and Total Harmonic Distortion
- 2.2.5.1 Power factor of greater than or equal to 0.9.
- 2.2.5.2 THD of less than or equal to 20 per cent.
- 2.2.6 0-10 V dimming, or as indicated on drawings.
- 2.2.7 Driver rated for minimum 50 000 hours.
- 2.2.8 Gasket: neoprene seal between refractor and housing.
- 2.2.9 Light Distributions:
- 2.2.9.1 Fixtures available with IES distribution types I, II, III, IV, V, and other distributions, as noted.
- 2.2.9.2 Pole mounted luminaire shall have an available option for low-profile house-side shield.
- 2.2.10 Self-locking latches of stainless steel and aluminum.
- 2.2.11 Factory wired including integral driver, terminated at terminal block.
- 2.2.12 Luminaires with cast aluminum weatherproof housing.
- 2.2.13 Ingress protection: sealed against moisture and environmental contaminants to IP65 rating or better for both light engines/optics and overall luminaire.
- 2.2.14 Finishes
- 2.2.14.1 Housing and heat sink finished in polyester powder coat paint, minimum 2.5 mil nominal thickness.
- 2.2.14.2 Standard finish colours to include black, bronze, grey, white, dark platinum, and graphite metallic.
- 2.2.14.3 RAL and custom colour matches to be available as indicated on the luminaire schedule.

2.3 OUTDOOR POLE/ARM MOUNTED AREA AND ROADWAY LED LUMINAIRES

- 2.3.1 Pole mounted luminaires suitable for the EPA rating of the pole.
- 2.3.2 Pole finish colour to match that of luminaire.
- 2.3.3 Source: Light Emitting Diode (LED).
- 2.3.3.1 Zonal Lumen Density:
- (1) 100 per cent between 0 degrees and 90 degrees from nadir.
-

- (2) Less than or equal to 10 per cent between 80 degrees and 90 degrees from nadir.

- 2.3.3.2 Minimum luminaire efficacy: 105 lumens per watt.
- 2.3.3.3 Correlated Colour Temperature (CCT): 3000 K.
- 2.3.3.4 Colour Rendition Index (CRI): 70 CRI minimum.
- 2.3.3.5 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with LM-80 testing data and TM-21 extrapolation. LM-80 testing is to utilize 10 000 hour testing data.

2.4 OUTDOOR WALL MOUNTED AREA LED LUMINAIRES

- 2.4.1 Source: Light Emitting Diode (LED).
 - 2.4.1.1 Zonal Lumen Density:
 - (1) 100 per cent between 0 degrees and 90 degrees from nadir.
 - (2) Less than or equal to 10 per cent between 80 degrees and 90 degrees from nadir.
 - 2.4.1.2 Minimum luminaire efficacy: 105 lumens per watt.
 - 2.4.1.3 Correlated Colour Temperature (CCT): 3000 K.
 - 2.4.1.4 Colour Rendition Index (CRI): 70 CRI minimum.
 - 2.4.1.5 Minimum L70 lumen maintenance to occur at 50 000 hours in accordance with LM-80 testing data and TM-21 extrapolation. LM-80 testing is to utilize 10 000 hour testing data.

2.5 FIXTURE MOUNTED CONTROLS PROVISION

- 2.5.1 Provide NEMA 7-pin receptacle on all pole mounted luminaires, complete with shorting cap.
 - 2.5.1.1 Shorting Cap, Locking-Type Mounting: 3-prong locking-type plug connector. It is used with luminaires with a photocontrol receptacle to complete circuit when a photocontrol is not required.
 - 2.5.1.2 Basis of design: Intermatic K4500 series.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install lighting equipment, including but not limited to luminaires, controls, auxiliary devices and the integration of same in strict conformance with all manufacturers' recommendations and instructions the securing of which shall be the responsibility of the Contractor.
 - 3.1.2 Luminaires shall be integrated with controls in accordance with respective luminaire manufacturers' and controls manufacturers' recommendations and instructions and to provide a complete, trouble-free operation without compromising safety, code and UL/CSA/NOM requirements.
 - 3.1.3 Contractor shall be responsible for sealing all outdoor luminaires for wet locations (i.e. all knock-outs, all pipe and wire entrances, etc.) as is standard industry practice to prevent water from entering luminaires.
 - 3.1.4 All luminaires shall be installed plumb and true and level as viewed from all directions unless specifically identified otherwise in the Luminaire Schedule portion (Article 2.12) of this Section. Luminaires shall remain plumb and true without continual adjustment or visibly obvious means beyond what is shown on luminaire submittal drawings.
 - 3.1.5 Luminaire finishes which are disturbed in any way during construction shall be touched up or refinished in a manner satisfactory to the Consultant.
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- 3.1.6 Whenever a luminaire or its hanger canopy is installed directly to a surface mounted junction box, a finishing ring painted to match the ceiling, shall be used to conceal the junction box.
- 3.1.7 All accessories shall be properly installed and adjusted by Contractor in accordance with specification and installation instructions. Any spare items shall be clearly labeled (indicate type of accessory and associated luminaire types).
- 3.1.8 Install luminaires on poles in accordance with Section 26 56 13.
- 3.1.9 For wall mounted luminaires:
 - 3.1.9.1 Provide a smooth grinding of brick, including type such as split face, to ensure a flush contact between luminaire and wall in accordance with Division 04 requirements.
 - 3.1.9.2 Provide a silicone seal around the luminaire.
- 3.1.10 Connect luminaire to lighting circuit.
 - 3.1.10.1 Fasten to luminaire with adhesive, or ties to maintain manufacturer's warranty on luminaire.
 - 3.1.10.2 Fastening by screws or nails: not permitted.

3.2 SITE TESTS AND INSPECTIONS

- 3.2.1 Perform lighting system commissioning in accordance with Section 26 08 50.
- 3.2.2 Perform light meter testing at night and report values to the Consultant.

3.3 ADJUSTING

- 3.3.1 As required, all adjustable luminaires shall be aimed, focused, locked, etc., by the Contractor under the observation of the Consultant. As aiming and adjusting is completed, locking setscrews and bolts and nuts shall be tightened securely by the Contractor.
- 3.3.2 All ladders, scaffolds, lifts, etc. required for aiming and adjusting luminaires shall be furnished by the Contractor.
- 3.3.3 Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing lighting effects, aiming shall be accomplished at night.

3.4 CLEANING

- 3.4.1 All luminaires and accessories shall be thoroughly cleaned after being installed. All fingerprints, dirt, tar, smudges, drywall mud and dust, etc. shall be removed by the Contractor from the luminaire bodies, reflectors, trims, and lens or louvers prior to final acceptance. All reflectors shall be free of paint other than factory-applied, if any. All reflectors, cones and lenses shall be cleaned only according to manufacturers' instructions.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Bell Canada New Building Conduit Requirements.
- 1.1.2 The requirements listed in this section are in addition to the requirements of various government agencies such as building codes, CSA standards, and the telecommunications provisioning standards as described by BICSI.
- 1.1.3 Under CRTC regulations, entrance conduits, equipment rooms, risers, runways, and other common pathways are considered as basic utility infrastructure that should be provided by the building owner/developer as part of construction. In addition, under Bell Canada's General Tariff, Terms of Service, Item 10, it is the property owner's responsibility to provide a conduit path from the property line to the building's telecommunication termination room (electrical room) and a conduit path from this room to any other buildings on the same private property.

1.2 COORDINATION

- 1.2.1 It is important to plan ahead to ensure necessary building services such as alarm circuits or elevator phones are in place as well as tenant services upon occupancy. To ensure that that these services are available when required, Bell Canada requires a scaled hard copy of the electrical site plan as well as a dwg and pdf file showing:
 - 1.2.1.1 The proposed entrance conduit location and length.
 - 1.2.1.2 The proposed telecommunication/electrical room location where the telecommunication cable will be terminated.
 - 1.2.1.3 The proposed inside riser system if applicable.
- 1.2.2 Note: Bell Canada will indicate locations acceptable to Bell if the proposed location is not suitable to Bell.

2 PRODUCTS

2.1 BUILDING ENTRANCE CONDUIT REQUIREMENTS

- 2.1.1 The following design considerations apply to the service entrance conduits:
 - 2.1.1.1 Must terminate within 3 m of the telecommunication backboard (fire retardant plywood).
 - 2.1.1.2 Preferred method: Between property line and the backboard located within the building's telecommunication termination room: Type 1 PVC 89 mm (3.5 in) or 100 mm (4.0 in) inside diameter concrete encased for mechanical protection. All conduits must be buried between the property line and the building on private property at a minimum depth of 610 mm (24 in) and at a maximum depth of 915 mm (36 in) to ensure adequate protection.
 - 2.1.1.3 Second Choice: Between property line and the backboard located within the building's telecommunication termination room: Type 1 PVC 89 mm (3.5 in) or 100 mm (4.0 in) inside diameter non-concrete encased. All conduits must be buried between the property line and the building on private property at a minimum depth of 610 mm (24 in) and at a maximum depth of 915 mm (36 in) to ensure adequate protection.
 - 2.1.1.4 Conduit termination at the property line to be marked with a 2" X 4" staked into the ground approximately 915 mm (3 ft) high.
 - 2.1.1.5 Inside the building, conduit must be EMT (Fire Rated – Electrical Metallic Tubing) 89 mm (3.5 in) or 100 mm (4.0 in) inside diameter. To ensure the successful placement and to avoid damaging the cable during the placing

operation, "1 metre" pull boxes are required at 90 degree bends within the building.

2.1.1.6 Conduit lengths over 30 m (100 ft) have a pull rope.

2.1.1.7 All conduits to be free and clear of obstructions.

2.1.1.8 Buildings with:

(1) 1 to 5 floors are provisioned with 1 service entrance conduit.

(2) 6 to 12 floors are provisioned with 2 service entrance conduits.

(3) >12 floors are provisioned as discussed with Bell Canada.

2.2 MAIN TELECOMMUNICATION ROOM/ELECTRICAL ROOM (INDOOR) REQUIREMENTS

2.2.1 The following is a list of the requirements and design consideration that must be applied when planning the telecommunication equipment room.

2.2.1.1 Room should be located in a dry area, not subjected to high temperatures, have adequate ventilation for the proper operation of equipment and should have adequate lighting conditions.

2.2.1.2 4' X 8' X 3/4" fire retardant plywood backboard fastened to wall in an area accessible without the use of a ladder where it is possible for a technician to work without blocking a passageway and where the equipment mounted will not be damaged by doors or any moving objects.

2.2.1.3 Accessible main building electrical ground (hydro ground); building grounds remote from the MTR made accessible via a conduit path (>30 m equipped with a pull rope).

2.2.1.4 AC power is required and is dependant on building design and the distance from the main electrical AC power panel. Requirements will be determined at a joint building site meeting.

2.3 BUILDING RISER CABLE

2.3.1 Bell Canada is responsible to provide facilities to the main telecommunication room. In addition, however, Bell Canada may provide riser cable and other in building cabling. Consult with your Bell Canada sales contact to determine if Bell will provide in building cabling to your project.

2.3.2 Should you not know who your Bell Canada sales contact is please contact the Bell Canada Integrated Business Solutions Centre at 1-800-929-2437. For service in English press 1 and then press 2 for Cabling.

2.3.3 The builder is responsible to ensure that the internal riser, horizontal and in-suite pathways are clear and free of obstruction, and that pull strings are installed in all conduits.

3 EXECUTION – NOT USED

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 This Section covers the Specification and requirements for the grounding and bonding of communications systems and structured cabling infrastructures.
- 1.1.2 Contractor shall provide all services, labor, materials, tools, and equipment required for the implementation of a complete and effective grounding and bonding System, as specified this Section.
- 1.1.3 Contractor shall comply with all the requirements of Specification, Design Drawings, and all applicable Telecommunications Standards and Electrical Codes.
- 1.1.4 Grounding and bonding System shall be designed, engineered, and installed to suit the Client's premises, communications systems and cabling infrastructure.
- 1.1.5 Grounding electrode system refers to all electrodes required by Electrical Code, including, telecommunications system grounding electrodes.
- 1.1.6 The terms "connect" and "bond" are used interchangeably in this Specification and have the same meaning.

1.2 DEFINITIONS

- 1.2.1 AWG – American Wire Gauge – The standardized system for gauging the diameter of round, solid, non-ferrous, electrically-conducting wire.
 - 1.2.2 BBC – Bonding Backbone Conductor – A telecommunications bonding connection which interconnects telecommunications bonding backbones. Formerly known as the grounding equalizer.
 - 1.2.3 BN – Bonding Network – A set of interconnected conductive structures that provides a low impedance path for the associated telecommunications infrastructure.
 - 1.2.4 EF – Entrance Facility – An entrance to a building for both public and private network service cables, including wireless, that includes the entrance point of the building and continues to the entrance room or space.
 - 1.2.5 ESD – Electrostatic Discharge – The sudden flow of electricity between two electrically-charged objects caused by contact, an electrical short, or dielectric breakdown.
 - 1.2.6 Mesh-BN – Mesh Bonding Network – A bonding network to which all associated equipment, such as cabinets, frames, racks, trays, and pathways, are connected using a bonding grid that is connected to multiple points on the common bonding network.
 - 1.2.7 PBB – Primary Bonding Busbar – A busbar placed in a convenient and accessible location and bonded, by means of the Telecommunications Bonding Conductor (TBC), to the building's service equipment (power) ground. Formerly known as the Telecommunications Main Grounding Busbar (TMGB).
 - 1.2.8 RBB – Rack Bonding Busbar – A busbar within a cabinet, frame, or rack.
 - 1.2.9 RBC – Rack Bonding Conductor – A bonding conductor from the rack or Rack Bonding Busbar (RBB) to the Telecommunications Equipment Bonding Conductor (TEBC).
 - 1.2.10 SBB – Secondary Bonding Busbar – A common point of connection for telecommunications system and equipment bonding to ground, located in the distributor room. Formerly known as the Telecommunications Grounding Busbar (TGB).
 - 1.2.11 TBB – Telecommunications Bonding Backbone – The conductor that interconnects the Primary Bonding Busbar (PBB) to the Secondary Bonding Busbar (SBB).
 - 1.2.12 TBC – Telecommunications Bonding Conductor – A conductor that interconnects the telecommunications bonding infrastructure to the building's service equipment (power) ground. Formerly known as the bonding conductor for telecommunications.
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- 1.2.13 TEBC – Telecommunications Equipment Bonding Conductor – A conductor that connects the Primary Bonding Busbar (PBB) or Secondary Bonding Busbar (SBB) to equipment racks or cabinets.
- 1.2.14 TR – Telecommunications Room – An enclosed space for housing telecommunications equipment, cable terminations, and cross-connect cabling. It is the recognized location of the cross-connect between the backbone and horizontal facilities.
- 1.2.15 UBC – Unit Bonding Conductor – A bonding conductor from equipment or a patch panel to a Rack Bonding Conductor (RBB) or a Rack Bonding Busbar (RBB).

1.3 REFERENCES

- 1.3.1 Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this Specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- 1.3.2 American Society for Testing and Materials (ASTM):
 - 1.3.2.1 ASTM-B1-13(2018) – Standard Specification for Hard-Drawn Copper Wire.
 - 1.3.2.2 ASTM B8-11(2017) – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- 1.3.3 Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1.3.3.1 IEEE 81-2012 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- 1.3.4 Canadian Standards Association (CSA):
 - 1.3.4.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
 - 1.3.4.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.3.5 Telecommunications Industry Association (TIA): Latest Revision of Standards
 - 1.3.5.1 TIA-606 – Administration Standard for Telecommunications Infrastructure
 - 1.3.5.2 TIA-607 – Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.
- 1.3.6 BICSI:
 - 1.3.6.1 Information Technology Systems Installation Methods Manual (ITSIMM), Recommended Testing Procedures and Criteria – Latest Revision
 - 1.3.6.2 Telecommunications Distribution Methods Manual (TDMM) – Latest Revision
- 1.3.7 Underwriters Laboratories, Inc. (UL):
 - 1.3.7.1 UL 44 (19th Edition, 2018) – UL Standard for Safety Thermoset-Insulated Wires and Cables.
 - 1.3.7.2 UL 83 (16th Edition, 2017) – UL Standard for Safety Thermoplastic-Insulated Wires and Cables.
 - 1.3.7.3 UL 467 (11th Edition, 2022) – UL Standard for Safety Grounding and Bonding Equipment.
 - 1.3.7.4 UL 486A-486B (3rd Edition, 2018) – UL Standard for Safety for Wire Connectors.
- 1.3.8 International Annealed Copper Standard (IACS)

1.4 SUBMITTALS

- 1.4.1 Submit in accordance with Section 01 33 00 and Section 27 10 00.
- 1.4.2 Action Submittals: Product Data for each type of product (PBB, SBB, RBB, 2-Hole Lugs, etc.)
- 1.4.3 Shop Drawings:
 - 1.4.3.1 Sufficient information, clearly presented, shall be included to determine compliance with latest TIA-607 Standard and this Specification.

- 1.4.3.2 Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Submit closeout documents in accordance with Section 27 10 00.
- 1.5.2 As-Built Data: Submit plans showing as-built locations of grounding and bonding infrastructure, including the following: PBB, SBB, RBB and routing of their bonding conductors.
- 1.5.3 Test Reports: Provide test reports of ground resistance to each primary or secondary bonding busbar (PBB/SBB) located in each telecommunications space impacted by the work.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Hubbell.
- 2.1.2 nVent Erico.
- 2.1.3 Panduit.
- 2.1.4 Thomas & Betts.

2.2 GENERAL REQUIREMENTS

- 2.2.1 Contractor shall provide a comprehensive and effective telecommunications grounding and bonding infrastructure for the protection of personnel and equipment, in compliance with the current Canadian Electrical Code, the latest TIA-607 Standard, and all applicable codes of Authority Having Jurisdiction (AHJ).
- 2.2.2 Grounding and bonding infrastructure shall follow the latest TIA-607 design methodology, whereby within a building the generic telecommunications bonding infrastructure originates at the facility's electrical entrance ground and extends throughout the building. The infrastructure shall comprise the following major components:
 - 2.2.2.1 Primary bonding busbar (PBB).
 - 2.2.2.2 Telecommunications bonding conductor (TBC).
 - 2.2.2.3 Telecommunications bonding backbone (TBB).
 - 2.2.2.4 Secondary bonding busbar (SBB).
 - 2.2.2.5 Backbone bonding conductor (BBC).
- 2.2.3 All cables shall be plenum rated FT6.
- 2.2.4 External Grounding Electrodes:
 - 2.2.4.1 The grounding electrode system shall be designed to have a resistance to earth of 25 ohms or less for a single grounding electrode.
 - 2.2.4.2 For sites that are critical in nature (e.g., public safety facilities, military installations, data centers, web hosting facilities, central offices) the grounding electrode system shall be designed to have a resistance of less than 10 ohms – ideally less than 5 ohms.

2.3 BONDING BUSBARS

- 2.3.1 Bonding busbars shall be provided in each telecommunications space (room/closet) and in each equipment rack/cabinet, as specified in this Section. Bonding busbars shall provide connection or termination points for the telecommunications space's bonding conductors.
 - 2.3.2 The types of bonding busbars specified in the infrastructure comprise:
 - 2.3.2.1 Primary Bonding Busbar (PBB)
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- 2.3.2.2 Secondary Bonding Busbar (SBB)
- 2.3.2.3 Rack Bonding Busbar (RBB)

2.4 PRIMARY BONDING BUSBAR (PBB)

- 2.4.1 The PBB shall be placed in a convenient and accessible location in the telecommunications entrance room or space. Typically, there should be a single PBB per building.
- 2.4.2 The PBB shall be bonded, by means of the telecommunications bonding conductor (TBC), to the building's service equipment (electrical) ground.
- 2.4.3 The PBB serves as the dedicated extension of the building grounding electrode system for the telecommunications infrastructure. It also serves as the central attachment point for the Secondary Bonding Busbars (SBB) through the Telecommunications Bonding Backbone (TBB).
- 2.4.4 The PBB shall be:
 - 2.4.4.1 Pre-drilled with mounting holes to accommodate matched listed lugs and hardware.
 - 2.4.4.2 Made of copper, or copper alloys having a minimum of 95% conductivity when annealed as specified by the International Annealed Copper Standard (IACS).
 - 2.4.4.3 Of minimum dimensions of 6.35 mm (0.25 in) thick x 100 mm (4 in) wide and variable in length to accommodate design requirements.
 - 2.4.4.4 UL Listed.
 - 2.4.4.5 Cleaned with an antioxidant applied prior to fastening connectors to the busbar.
 - 2.4.4.6 Insulated from its support using an insulator that is listed for the purpose by a nationally recognized testing laboratory (NRTL).
 - 2.4.4.7 Installed a minimum of 50 mm (2 in) from the finished wall to allow access to the rear of the busbar.
 - 2.4.4.8 Sized for current applications and future growth.
- 2.4.5 The primary protector grounding conductor shall be connected to the PBB. This conductor is intended to conduct lightning and AC fault currents from the telecommunication primary protectors.

2.5 SECONDARY BONDING BUSBAR (SBB)

- 2.5.1 The SBB shall be placed in a convenient location of the telecommunications room/closet. The SBB shall form a common bonding connection point for telecommunications systems and equipment in the area served by the telecommunications room/closet.
- 2.5.2 The SBB shall be:
 - 2.5.2.1 Pre-drilled with mounting holes to accommodate matched UL Listed lugs and hardware.
 - 2.5.2.2 Made of copper, or copper alloys having a minimum of 95% conductivity when annealed as specified by the International Annealed Copper Standard (IACS).
 - 2.5.2.3 Of minimum dimensions of 6.35 mm (0.25 in) thick x 50 mm (2 in) wide and variable in length.
 - 2.5.2.4 cUL Listed.
 - 2.5.2.5 Cleaned with an antioxidant applied prior to fastening connectors to the busbar.
 - 2.5.2.6 Insulated from its support using an insulator that is listed for the purpose by a nationally recognized testing laboratory (NRTL).
 - 2.5.2.7 Installed at a minimum of 50 mm (2 in) from the finished wall to allow access to the rear of the busbar.
 - 2.5.2.8 Sized for current applications and future growth.

2.6 RACK BONDING BUSBAR (RBB)

- 2.6.1 The RBB is a grounding busbar within a cabinet, rack, or frame.
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- 2.6.2 The RBB shall be provided in cabinets and racks that support multiple equipment bonding conductors to serve as an extension of the PBB or SBB for the equipment in the cabinet.
- 2.6.3 The RBB shall meet the following requirements:
 - 2.6.3.1 Manufactured from copper alloy.
 - 2.6.3.2 cUL Listed.
 - 2.6.3.3 Horizontal Busbars shall be at least 19 mm (0.75 in) wide, 483 mm (19 in) long, and 5 mm (0.1875 in) thick.
 - 2.6.3.4 Have a minimum of 14, factory-provided #12–24 threaded holes.
 - 2.6.3.5 Have pre-punched EIA 310 D standard rack mounting holes.
 - 2.6.3.6 Vertical Busbars shall be at least 17 mm (0.67 in) wide, 2 m (78.65 in) long, and 1.27 mm (0.05 in) thick, and shall come in threaded rail and cage nut versions.

2.7 BONDING CONDUCTORS

- 2.7.1 The following common requirements apply to all types of bonding conductors specified in this Section:
 - 2.7.1.1 All bonding conductors shall be made of stranded copper wire with a green jacket (or per CE Code depending on size), run as a continuous conductor.
 - 2.7.1.2 Bonding conductors may be insulated. If insulated they shall be cUL Listed for the application.
 - 2.7.1.3 Bonding conductors shall be protected from physical and mechanical damage.
 - 2.7.1.4 Bonding conductors shall be sized to meet the ANSI/TIA-607-D requirements.
- 2.7.2 Telecommunications Bonding Backbone (TBB)
 - 2.7.2.1 The TBB is a conductor that bonds the Secondary Bonding Busbars (SBB) to the Facility's Primary Bonding Busbar (PBB).
 - 2.7.2.2 The TBB shall meet the following requirements:
 - (1) The TBB shall be sized to meet the requirements of ANSI/TIA-607-D and shall be as straight as practicable avoiding bends. The TBB minimum conductor size shall be AWG 6.
 - (2) Bonding and grounding conductors may be insulated or un-insulated and shall not decrease in size as the grounding path moves closer to earth.
 - (3) Connections (bonds) between the telecommunications grounding network and associated electrical panels shall be done by a qualified electrician in accordance with guidelines in the latest TIA-607 and applicable electrical codes.
 - (4) Bonding Conductors should be continuous (splices not allowed) and routed in the shortest possible straight-line path, avoiding changes in elevation and sharp bends.
 - (5) TBB grounding conductors routing through ferrous metal conduit should be avoided, but if it is necessary due to building constraints, any grounding conductor running through ferrous conduit longer than 3 feet shall be bonded at the end using appropriately sized conduit grounding clamps as described TIA-607.
 - (6) Bonding the TBB to the PBB and each SBB shall be performed with a UL listed irreversible compression (crimp) dual-lug connector.
 - (7) Metallic cable shield(s) and cabling pathways, including metallic conduits, shall not be used as a TBB.
 - (8) Whenever two (2) or more TBBs are used within a multistory building, the TBBs shall be bonded together with a BBC at every third floor as a minimum, and at the top floor.

- (9) Conductor sizing depends upon the Project specification, and shall be determined based on the TBB length as stipulated in TIA-607. Contractor shall ensure TBB sizing complies with the TIA-607 guidelines outlined in the Table below:

<u>Sizing of the TBB</u>	
<u>TBB Length in Linear Meters (Feet)</u>	<u>TBB Size (AWG)</u>
Less than 4 (13)	6
4-6 (14-20)	4
6-8 (21-26)	3
8-10 (27-33)	2
10-13 (34-41)	1
13-16 (42-52)	1/0
16-20 (53-66)	2/0
20-26 (67-84)	3/0
26-32 (85-105)	4/0
32-38 (106-125)	250 kcmil
38-46 (126-150)	300 kcmil
46-53 (151-175)	350 kcmil
53-76 (176-250)	500 kcmil
76-91 (251-300)	600 kcmil
Greater than 91 (301)	750 kcmil

- 2.7.3 Telecommunications Bonding Conductor (TBC)
- 2.7.3.1 The TBC connects the telecommunications bonding infrastructure to the building's service equipment (power) ground (formerly known as the bonding conductor for telecommunications).
- 2.7.3.2 The TBC shall have at a minimum the same size as the largest TBB.
- 2.7.3.3 The TBC shall bond the PBB to the service equipment (power) ground.
- 2.7.4 Backbone Bonding Conductor (BBC)
- 2.7.4.1 The BBC (formerly known as the grounding equalizer) is a bonding conductor which interconnects telecommunications bonding backbones.
- 2.7.4.2 The BBC shall have at a minimum the same size as the largest TBB to which it is bonded.
- 2.7.5 Telecommunications Equipment Bonding Conductor (TEBC)
- 2.7.5.1 The TEBC is a bonding conductor which connects the cabinets and racks in a telecommunications room/closet to the local primary or secondary bonding busbar (PBB or SBB).
- 2.7.5.2 The TEBC shall have a minimum size of AWG 6.

- 2.7.5.3 Metallic objects and pathways shall not be used as a replacement for the TEBC.
- 2.7.5.4 The TEBC may be routed inside cable trays. It shall be secured at maximum intervals of 0.9 m (3 ft).
- 2.7.5.5 The TEBC shall be separated a minimum of 50.8 mm (2 in) from other cable groups, such as power or telecommunications cables.
- 2.7.5.6 The TEBC shall be connected to the cabinets/racks, to a Rack Bonding Conductor (RBC) or to a vertical/horizontal Rack Bonding Busbar (RBB).
- 2.7.5.7 Connections to the TEBC shall be made with UL Listed irreversible compression connectors, suitable for multiple conductors, and with the rack bonding conductors (RBCs) routed toward the PBB/SBB.
- 2.7.6 Rack Bonding Conductor (RBC)
 - 2.7.6.1 The RBC is a bonding conductor from the cabinet or Rack Bonding Busbar (RBB) to the Telecommunications Equipment Bonding Conductor (TEBC).
 - (1) The RBC shall have a minimum size of AWG 6.
 - (2) The RBC shall be bonded to the Telecommunications Equipment Bonding Conductor (TEBC) using UL Listed irreversible compression (crimp) connectors.
 - (A) Where connected to a server cabinet, the RBC extends to the bottom of the server cabinet allowing Equipment Bonding Conductors to be attached at any point in the cabinet.
 - (B) Where connected to a network rack/cabinet, the Rack Bonding Conductor (RBC) is bonded to the Rack Bonding Busbar (RBB) via a UL Listed two-hole compression lug.
 - 2.7.6.2 Unit Bonding Conductor (UBC)
 - (1) The Unit Bonding Conductor (UBC) connects individual equipment in a cabinet or rack to the Rack Bonding Conductor (RBC) or Rack Bonding Busbar (RBB).
 - (2) The UBC shall also be used for bonding cable tray sections to the Telecommunications Equipment Bonding Conductor (TEBC).
 - (3) The UBC shall have a minimum size of AWG 6.
 - (4) Bonding.
 - (A) Where used in a server cabinet, UBC shall be bonded to the Rack Bonding Connector (RBC) using UL Listed irreversible compression (crimp) connectors and to IT equipment via a UL Listed two-hole compression lug. (Some IT equipment may require one-hole lugs.)
 - (B) Where used in a network cabinet/rack, UBC shall be bonded to the Rack Bonding Busbar (RBB) via a UL Listed two-hole compression lug and to IT equipment via a UL Listed two-hole compression lug. (Some IT equipment may require one-hole lugs.)
 - (C) Where used as a cable tray bonding conductor connecting cable tray sections, UBC shall be bonded to each adjoining section of the cable tray using UL Listed two-hole compression lugs.
 - (D) Where used as a cable tray bonding conductor connecting cable tray sections to the Telecommunications Equipment Bonding Conductor (TEBC), UBC shall be bonded to the TEBC using UL Listed irreversible compression (crimp) connectors and to the cable tray via a UL Listed two-hole compression lug.

3 EXECUTION

3.1 GENERAL

- 3.1.1 Ground in compliance with the CE Code, the latest TIA-607 Standard, and as specified in this Section and the Drawings.
- 3.1.2 Components of the telecommunications bonding system shall be installed and connected using materials and techniques as specified in the latest TIA-607 Standard.
- 3.1.3 Follow equipment manufacturer's grounding instructions.

3.2 EXAMINATION

- 3.2.1 Contractor shall check the AC grounding electrode system and equipment grounding for compliance with the requirements for maximum ground-resistance level, and other conditions affecting performance of grounding and bonding of the telecommunications system.
- 3.2.2 Inspect the test results of the AC grounding system.
- 3.2.3 Prepare written report listing all conditions detrimental to the performance of the Work.
- 3.2.4 Proceed with Work only after unsatisfactory conditions have been corrected.

3.3 CORROSION INHIBITORS

- 3.3.1 When making ground and bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.
- 3.3.2 PBB and SBB shall always have tinned surfaces to restrain oxidation and shall be cleaned and have an antioxidant paste applied to both bonding surfaces prior to fastening conductors.

3.4 TELECOMMUNICATIONS SYSTEM GROUNDING

- 3.4.1 Bond the telecommunications grounding system to the electrical grounding electrode system.
 - 3.4.2 Provide dedicated telecommunications grounding busbars for the following locations/spaces:
 - 3.4.2.1 Telecom entrance facility rooms
 - 3.4.2.2 Server rooms
 - 3.4.2.3 IT rooms/closets
 - 3.4.3 Provide bonding to all telecom cabinets, racks, metallic cable shields, junction/pull boxes, enclosures, and communications/security equipment, as required by Standards and Code.
 - 3.4.4 Provide bonding to all metallic cable trays and conduits to building ground.
 - 3.4.5 Bond incoming carrier armor sheath to building ground.
 - 3.4.6 Furnish and install all busbars and bonding conductors required to properly ground and bond all communications raceways, cable trays, metallic cable shields, and equipment, in compliance with design, Codes and Standards.
 - 3.4.7 Bonding jumpers/conductors shall be continuous with no splices. Use the shortest possible length of bonding jumper.
 - 3.4.8 Provide ground paths that are permanent and continuous with a resistance of 1 ohm or less from raceway, cable tray, and equipment connections to the building grounding electrode. The resistance across individual bonding connections shall be 10 milliohms or less.
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- 3.4.9 Above-Grade Grounding Connections: When making bolted or screwed connections to attach bonding conductors, remove paint to expose the entire contact surface by grinding where necessary; thoroughly clean all connector, plate and other contact surfaces; and apply an appropriate corrosion inhibitor to all surfaces before joining.
- 3.4.10 Bonding Conductors:
 - 3.4.10.1 Use insulated ground wire of the size and type shown on the Drawings or use a minimum of #6 AWG insulated copper wire.
 - 3.4.10.2 Assemble bonding jumpers using insulated ground wire terminated with compression connectors.
 - 3.4.10.3 Use compression connectors of proper size for the specified conductors. Use connector manufacturer's compression tool.
- 3.4.11 Bonding Jumper Fasteners:
 - 3.4.11.1 Conduit: Fasten bonding jumpers using screw lugs on grounding bushings or conduit strut clamps, or the clamp pads on push-type conduit fasteners. When screw lug connection to a conduit strut clamp is not possible, fasten the plain end of a bonding jumper wire by slipping the plain end under the conduit strut clamp pad; tighten the clamp screw firmly. Where appropriate, use zinc-plated external tooth lockwashers.
 - 3.4.11.2 Wireway and Cable Tray: Fasten bonding jumpers using zinc-plated bolts, external tooth lockwashers, and nuts. Install protective cover, e.g., zinc-plated acorn nuts on any bolts extending into wireway or cable tray to prevent cable damage.
 - 3.4.11.3 Ground Plates and Busbars: Fasten bonding jumpers using two-hole compression lugs. Use tin-plated copper or copper alloy bolts, external tooth lockwashers, and nuts.
 - 3.4.11.4 Strut Channel and Raised Floor Stringers: Fasten bonding jumpers using zinc-plated, self-drill screws and external tooth lockwashers.

3.5 RACEWAY GROUNDING

- 3.5.1 Conduit: Use insulated #6 AWG bonding jumpers to ground metallic conduit at each end and to bond at all intermediate metallic enclosures.
- 3.5.2 Cable Tray: Use insulated #6 AWG bonding jumpers to ground metallic cable tray at:
 - 3.5.2.1 Each end
 - 3.5.2.2 All intermediate metallic enclosures/boxes
 - 3.5.2.3 All cable tray section junctions

3.6 IDENTIFICATION AND ADMINISTRATION

- 3.6.1 Provide complete grounding system labeling in accordance with the requirements of:
 - 3.6.1.1 ANSI/TIA-606, Latest Revision
 - 3.6.1.2 Section 27 05 53 – Identification for Communications Systems.
- 3.6.2 Primary Bonding Busbar (PBB): Label with "PBB".
- 3.6.3 Secondary Bonding Busbar (SBB): Label with "SBB".
- 3.6.4 Telecommunications Bonding Backbone (TBB): Label with "WARNING! TELECOMMUNICATIONS BONDING BACKBONE. DO NOT REMOVE OR DISCONNECT" Labels shall be affixed at both ends and at accessible intermediate points.

3.7 TESTING

- 3.7.1 Perform tests as specified in BICSI Information Technology Systems Installation Methods Manual (ITSIMM), Recommended Testing Procedures and Criteria.
 - 3.7.2 Perform two-point bond testing to be preformed by qualified technicians.
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- 3.7.3 Conduct continuity tests to verify that all metallic pathways and pathway sections are bonded to PBB or SBB.
- 3.7.4 Conduct electrical continuity test to verify that PBB is effectively bonded to the facility grounding electrode conductor.
- 3.7.5 Perform resistance tests to ensure rack and cabinet bonding connection resistance measures less than 4 Ω to PBB or SBB.
- 3.7.6 Provide a complete test report to Consultant and Owner.

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Provide a complete system of empty conduit, pull boxes, outlets, and sleeves for enclosure of communications cabling.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 33.13 – Conduit for Electrical Systems.
1.2.2 Section 26 05 33.16 – Boxes for Electrical Systems.

1.3 REFERENCES

- 1.3.1 BISCII Telecommunications Distribution Methods Manual, 14th Edition.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Record documentation:
1.4.1.1 Records of underground utility locates.
1.4.1.2 Record as-constructed location of all underground conduits and telecommunications pathways on as-built drawings regardless of conduit size.

2 PRODUCTS

2.1 OUTLETS

- 2.1.1 Wall outlets shall be 115 mm square boxes with plaster rings to suit single gang devices unless otherwise noted.
2.1.2 Provide 53 mm conduit through walls as noted.

2.2 CONDUITS

- 2.2.1 Conduit size shall be in accordance with recommended standard for conduits in Building as published by BICSI.
2.2.2 Minimum conduit size shall be 21 mm diameter.
2.2.3 Minimum space requirements in pull boxes for 90 degree pulls, shall be as follows:

Maximum conduit size	Size of pull boxes in millimetres			For each additional conduit size increase width by:
	Width	Length	Depth	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 2.2.4 Plenum cables are permitted in accessible ceilings. Provide 'J' hooks in these locations for cable installation.
2.2.5 Plywood backboards shall be minimum 1200 mm by 2400 mm, 19 mm thick, painted with 2 coats of fire retardant light grey enamel.
2.2.6 Provide a minimum of two 5-15R duplex receptacles on separate circuits at each backboard.
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3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Vertically mount outlet boxes, unless noted otherwise, 300 mm to centre above floor, or 150 mm above counter top where shown at counters or benches.
- 3.1.2 Fish conduit, clear blockages and outlet and clean out pull boxes at completion of installation. Leave conduit free of water or excess moisture. Install No. 12 gauge galvanized soft iron pull wire, or 3.2 mm (1/8") nylon pull cord continuously from outlet to outlet, through conduit and fasten at each box.
- 3.1.3 Conduit shall have a bending radius of not less than nine times conduit diameter. Ream out conduit and identify ends with green paint.
- 3.1.4 Install additional steel pull boxes in such a manner that, throughout entire system, there shall be not more than two 90 degree or equivalent bends or more than 30 m in each run, so that wire or cables may be pulled in or withdrawn with reasonable ease. Minimum space requirements in pull boxes having one conduit each in opposite ends of the box, shall be as follows:

Maximum conduit size	Size of pull boxes in millimetres			For each additional conduit size increase width by:
	Width	Length	Depth	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 3.1.5 Show as-installed conduit routing and location of all pull boxes on the record drawings, prior to project completion, for use by future installer to facilitate wiring and equipment installation. Include above noted information on final record drawings at project completion.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Provide a complete system of empty conduits, pull boxes, outlets, and sleeves for enclosure of public address system including the following devices:
- 1.1.1.1 Speakers:
- (1) Wall mounted in apparatus bay.
 - (2) Ceiling mounted throughout balance of fire station. Refer to drawings for ceiling types.
- 1.1.1.2 Door bells.
- 1.1.1.3 Public Address system equipment.
- 1.1.1.4 Volume controls in the following spaces:
- (1) Private offices.
 - (2) Dorms.
 - (3) Fitness rooms.
 - (4) Meeting Rooms.
 - (5) Kitchen.
 - (6) Dining area.
 - (7) Lounge.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 33.13 – Conduit for Electrical Systems.
- 1.2.2 Section 26 05 33.16 – Boxes for Electrical Systems.
- 1.2.3 Section 28 46 13 – Fire-Alarm Systems.

1.3 REFERENCES

- 1.3.1 BISC I Telecommunications Distribution Methods Manual, 13th Edition (2014).

2 PRODUCTS

2.1 OUTLETS

- 2.1.1 Wall outlets shall be 115 mm square boxes with plaster rings to suit single gang devices unless otherwise noted.

2.2 CONDUITS

- 2.2.1 Conduit size shall be in accordance with recommended standard for conduits in Building as published by BICSI.
- 2.2.2 Minimum conduit size shall be 21 mm diameter.
- 2.2.3 Minimum space requirements in pull boxes for 90 degree pulls, shall be as follows:

<u>Maximum conduit size</u>	<u>Size of pull boxes in millimetres</u>			<u>For each additional conduit size increase width by:</u>
	<u>Width</u>	<u>Length</u>	<u>Depth</u>	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm

41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 2.2.4 Plenum cables are permitted in accessible ceilings. Provide 'J' hooks in these locations.
- 2.2.5 Plywood backboards shall be minimum 1200 mm by 2400 mm, 19 mm thick, painted with two coats of fire retardant light grey enamel.
- 2.2.6 Provide a minimum of two duplex receptacles on separate circuits at each backboard.
- 2.2.7 Provide fire alarm over-ride feature at fire alarm control panel (FACP) to deactivate public address system when Fire Alarm System is in alarm.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Vertically mount outlet boxes, unless noted otherwise, 300 mm to centre above floor, or 150 mm above counter top where shown at counters or benches.
- 3.1.2 Fish conduit, clear blockages and outlet and clean out pull boxes at completion of installation. Leave conduit free of water or excess moisture. Install No. 12 gauge galvanized soft iron pull wire, or 3.2 mm (1/8") nylon pull cord continuously from outlet to outlet, through conduit and fasten at each box.
- 3.1.3 Conduit bonds shall have a bending radius of not less than nine times conduit diameter. Ream out conduit and identify ends with green paint.
- 3.1.4 Install additional steel pull boxes in such a manner that, throughout entire system, there shall be not more than two 90 degree or equivalent bends or more than 30 000 mm in each run, so that wire or cables may be pulled in or withdrawn with reasonable ease. Minimum space requirements in pull boxes having one conduit each in opposite ends of the box, shall be as follows:

<u>Maximum conduit size</u>	<u>Size of pull boxes in millimetres</u>			<u>For each additional conduit size increase width by:</u>
	<u>Width</u>	<u>Length</u>	<u>Depth</u>	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 3.1.5 Show as-installed conduit routing and location of all pull boxes on the record drawings, prior to project completion.

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Provide a complete system of empty conduits, terminal cabinets, plywood backboards, pull boxes and outlets for enclosure of wiring by Security Contractor.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 33.13 – Conduit for Electrical Systems.
- 1.2.2 Section 26 05 33.16 – Boxes for Electrical Systems.

1.3 ALLOWANCES

- 1.3.1 Refer to Section 01 21 13 – Cash Allowances.
- 1.3.2 Work by the City's assigned security vendor to be retained by the Contractor under the cash allowance includes supply and installation of the following:
 - 1.3.2.1 Relay to interface in Access Control/Security System to connect to the Public Address System for "bing/bong" (door bell) sounder.
 - 1.3.2.2 Relays for interface to overhead door operators.
 - 1.3.2.3 Card reader on each of the apparatus bay vehicle doors.
 - 1.3.2.4 Card reader and associated devices on door to rear side of fire engine garage.
 - 1.3.2.5 Card reader and associated devices on dayroom lounge door from exterior – rear.
 - 1.3.2.6 Card reader and associated devices on IT room door.
 - 1.3.2.7 Card reader and associated devices on staff entry side door (to vestibule) – interface to automatic door operator.
 - 1.3.2.8 Card reader and associated devices on door to bay vestibule – interface to automatic door operator.
 - 1.3.2.9 Card reader and associated devices on inner vestibule door (Vestibule 100) – interface to automatic door operator.
 - 1.3.2.10 AMAG panels, power supplies, NIC module, and back up batteries included.
 - 1.3.2.11 Project management, cabling, programming, and cad drawings included.
 - 1.3.2.12 Security cabling included.
- 1.3.3 Work by this contractor that is not part of the security vendor's scope of work:
 - 1.3.3.1 Interface cabling from Access Control/Security system to Public Address System for "bing/bong" (door bell) sounder.
 - 1.3.3.2 All network equipment and IP addressing by Owner's IT staff.
 - 1.3.3.3 All conduit, raceways, cable trough, junction boxes, fire rated plywood and 110 V power.

2 PRODUCTS

2.1 OUTLETS

- 2.1.1 Wall and door outlets shall be single boxes, or 115 mm square boxes with plaster rings to suit single gang devices unless otherwise noted. Coordinate with Security Contractor.

2.2 CONDUITS

- 2.2.1 Provide conduit in all walls, exposed areas, and inaccessible ceilings. All conduit work shall be concealed.
 - 2.2.2 Minimum conduit size shall be 21 mm diameter.
 - 2.2.3 Provide J hooks in accessible ceilings for plenum rated wiring.
-

- 2.2.4 Minimum space requirements in pull boxes for 90 degree pulls, shall be as follows:

<u>Maximum conduit size</u>	<u>Size of pull boxes in millimetres</u>			<u>For each additional conduit size increase width by:</u>
	<u>Width</u>	<u>Length</u>	<u>Depth</u>	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 2.2.5 Plywood backboards shall be minimum 1200 x 2400 mm, 19 mm thick, painted with 2 coats of fire retardant light grey enamel.

- 2.2.6 Provide a minimum of 2 duplex receptacles on separate circuits at each backboard.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Vertically mount outlet boxes, unless noted otherwise, 300 mm to centre above floor, or 150 mm above counter top where shown at counters or benches.
- 3.1.2 Fish conduit, clear blockages and outlet and clean out pull boxes at completion of installation. Leave conduit free of water or excess moisture. Install No. 12 gauge galvanized soft iron pull wire, or 3.2 mm (1/8") nylon pull cord continuously from outlet to outlet, through conduit and fasten at each box.
- 3.1.3 Conduit bonds shall have a bending radius of not less than nine times conduit diameter. Ream out conduit and identify ends with green paint.
- 3.1.4 Install additional steel pull boxes in such a manner that, throughout entire system, there shall be not more than two 90 degree or equivalent bends or more than 30 m in each run, so that wire or cables may be pulled in or withdrawn with reasonable ease. Minimum space requirements in pull boxes having one conduit each in opposite ends of the box, shall be as follows:

<u>Maximum conduit size</u>	<u>Size of pull boxes in millimetres</u>			<u>For each additional conduit size increase width by:</u>
	<u>Width</u>	<u>Length</u>	<u>Depth</u>	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 3.1.5 Show as-installed conduit routing and location of all pull boxes on the record drawings, prior to project completion, for use by Security installer to facilitate wiring and equipment installation. Include above noted information on final record drawings at project completion.

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Provide a complete system of empty conduits, terminal cabinets, plywood backboards, pull boxes and outlet boxes for enclosure data of cabling for this system.
- 1.1.2 Provide data cabling for each drop to each CCTV camera.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 33.13 – Conduit for Electrical Systems.
- 1.2.2 Section 26 05 33.16 – Boxes for Electrical Systems.

1.3 ALLOWANCES

- 1.3.1 Refer to Section 01 21 13 – Cash Allowances.
- 1.3.2 Work by the City's assigned security vendor to be retained by the Contractor under the cash allowance includes supply and installation of the following:
 - 1.3.2.1 Avigilon fixed dome IP camera in Vestibule 100.
 - 1.3.2.2 Two Avigilon multisensor cameras on building exterior (180 degree and 270 degree) with appropriate mounting hardware.
 - 1.3.2.3 One Avigilon corner mount bracket.
 - 1.3.2.4 Avigilon camera licenses, PoE injectors and IR illuminators for exterior cameras.
 - 1.3.2.5 Project management, cabling, programming, and CAD drawings included.
- 1.3.3 Work by this contractor that is not part of the security vendor's scope of work:
 - 1.3.3.1 All network equipment and IP addressing by Owner's IT staff.
 - 1.3.3.2 All conduit, raceways, cable trough, junction boxes, fire rated plywood and 110 V power.
 - 1.3.3.3 Category 6 cabling to video surveillance cameras.

2 PRODUCTS

2.1 VIDEO SURVEILLANCE EQUIPMENT

- 2.1.1 Video Surveillance equipment shall be based on IP cameras. Size conduits based on industry practices based on Category 6 communications cabling.

2.2 OUTLETS

- 2.2.1 Wall and door outlets shall be single boxes, or 115 mm square boxes with plaster rings to suit single gang devices unless otherwise noted. Coordinate with Owner's video surveillance contractor.

2.3 CONDUITS

- 2.3.1 Provide conduit in all walls, exposed areas, and inaccessible ceilings. All conduit work shall be concealed.
- 2.3.2 Minimum conduit size shall be 21 mm diameter.
- 2.3.3 Provide J hooks in accessible ceilings for plenum rated wiring.
- 2.3.4 Minimum space requirements in pull boxes for 90 degree pulls, shall be as follows:

<u>Maximum conduit size</u>	<u>Size of pull boxes in millimetres</u>			<u>For each additional conduit size increase width by:</u>
	<u>Width</u>	<u>Length</u>	<u>Depth</u>	
21 mm	150 mm	300 mm	100 mm	50 mm

27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 2.3.5 Plywood backboards shall be minimum 1200 mm by 2400 mm, 19 mm thick, painted with 2 coats of fire retardant light grey enamel.
- 2.3.6 Provide a minimum of two duplex receptacles on separate circuits at each backboard.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Vertically mount outlet boxes, unless noted otherwise, 300 mm to centre above floor, or 150 mm above counter top where shown at counters or benches.
- 3.1.2 Fish conduit, clear blockages and outlet and clean out pull boxes at completion of installation. Leave conduit free of water or excess moisture. Install No. 12 gauge galvanized soft iron pull wire, or 3.2 mm (1/8") nylon pull cord continuously from outlet to outlet, through conduit and fasten at each box.
- 3.1.3 Conduit bonds shall have a bending radius of not less than nine times conduit diameter. Ream out conduit and identify ends with green paint.
- 3.1.4 Install additional steel pull boxes in such a manner that, throughout entire system, there shall be not more than two 90 degree or equivalent bends or more than 30 000 mm in each run, so that wire or cables may be pulled in or withdrawn with reasonable ease. Minimum space requirements in pull boxes having one conduit each in opposite ends of the box, shall be as follows:

<u>Maximum conduit size</u>	<u>Size of pull boxes in millimetres</u>			<u>For each additional conduit size increase width by:</u>
	<u>Width</u>	<u>Length</u>	<u>Depth</u>	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 3.1.5 Show as-installed conduit routing and location of all pull boxes on the record drawings, prior to project completion, for use by Security installer to facilitate wiring and equipment installation. Include above noted information on final record drawings at project completion.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Provide a complete system of empty conduits, pull boxes, outlets, and sleeves for enclosure of fire station alerting system.
- 1.1.2 Provide a complete system of empty conduits, pull boxes, outlets, and sleeves for the enclosure of the traffic pre-emption system.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 33.13 – Conduit for Electrical Systems.
- 1.2.2 Section 26 05 33.16 – Boxes for Electrical Systems.
- 1.2.3 Section 28 46 13 – Fire-Alarm Systems.
- 1.2.4 Appendix E3 – Motorola Mach Alert Fire Station Alerting System Documentation.

1.3 REFERENCES

- 1.3.1 BISCI Telecommunications Distribution Methods Manual, 13th Edition (2014).

2 PRODUCTS

2.1 DEVICES

- 2.1.1 Wall outlets for shall be 115 mm square boxes with plaster rings to suit single gang devices unless otherwise noted.
- 2.1.2 Provide conduit from IT room to response time tracking clocks (locations to be confirmed), and response push buttons.

2.2 CONDUITS

- 2.2.1 Conduit size shall be in accordance with recommended standard for conduits in Building as published by BICSI.
- 2.2.2 Minimum conduit size shall be 21 mm diameter.
- 2.2.3 Minimum space requirements in pull boxes for 90 degree pulls, shall be as follows:

Maximum conduit size	Size of pull boxes in millimetres			For each additional conduit size increase width by:
	Width	Length	Depth	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 2.2.4 Plenum cables are permitted in accessible ceilings. Provide 'J' hooks in these locations.
- 2.2.5 Plywood backboards shall be minimum 1200 mm by 2400 mm, 19 mm thick, painted with two coats of fire retardant light grey enamel.
- 2.2.6 Provide a minimum of two duplex receptacles on separate circuits at each backboard.
- 2.2.7 Provide fire alarm over-ride feature at fire alarm control panel (FACP) to deactivate public address system when Fire Alarm System is in alarm.

2.3 ROOFTOP ANTENNA CONDUITS

- 2.3.1 Provide three 53 mm (2") conduits from rip & run printer to the roof of the apparatus bay.
Provide gooseneck fitting.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Vertically mount outlet boxes, unless noted otherwise, 300 mm to centre above floor, or 150 mm above counter top where shown at counters or benches.
- 3.1.2 Fish conduit, clear blockages and outlet and clean out pull boxes at completion of installation. Leave conduit free of water or excess moisture. Install No. 12 gauge galvanized soft iron pull wire, or 3.2 mm (1/8") nylon pull cord continuously from outlet to outlet, through conduit and fasten at each box.
- 3.1.3 Conduit bonds shall have a bending radius of not less than nine times conduit diameter. Ream out conduit and identify ends with green paint.
- 3.1.4 Install additional steel pull boxes in such a manner that, throughout entire system, there shall be not more than two 90 degree or equivalent bends or more than 30 000 mm in each run, so that wire or cables may be pulled in or withdrawn with reasonable ease. Minimum space requirements in pull boxes having one conduit each in opposite ends of the box, shall be as follows:

<u>Maximum conduit size</u>	<u>Size of pull boxes in millimetres</u>			<u>For each additional conduit size increase width by:</u>
	<u>Width</u>	<u>Length</u>	<u>Depth</u>	
21 mm	150 mm	300 mm	100 mm	50 mm
27 mm	200 mm	400 mm	150 mm	75 mm
35 mm	250 mm	450 mm	200 mm	75 mm
41 mm	300 mm	600 mm	250 mm	100 mm
53 mm	350 mm	750 mm	300 mm	125 mm

- 3.1.5 Show as-installed conduit routing and location of all pull boxes on the record drawings, prior to project completion.

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 The work covered under this section consists of the furnishing of all necessary labour, supervision, materials, equipment, and services to completely execute the system of non-continuous cable supports ("J-Hooks") as described in this specification.

1.2 SCOPE

- 1.2.1 Non-continuous cable supports.
- 1.2.2 Adjustable non-continuous cable support sling.
- 1.2.3 Multi-tiered non-continuous cable support assemblies.
- 1.2.4 Non-continuous cable support assemblies from tee bar.
- 1.2.5 Non-continuous cable support assemblies from drop wire/ceiling.
- 1.2.6 Non-continuous cable support assemblies from beam, flange.
- 1.2.7 Non-continuous cable support assemblies from C & Z Purlin.
- 1.2.8 Non-continuous cable support assemblies from wall, concrete, or joist.
- 1.2.9 Non-continuous cable support assemblies from threaded rod.
- 1.2.10 Raised floor non-continuous cable support assemblies.
- 1.2.11 Cantilever-Mounted Option for non-continuous cable supports.
- 1.2.12 Installation accessories for non-continuous cable supports.

1.3 DEFINITIONS

- 1.3.1 UTP: Unshielded twisted pair.
- 1.3.2 ANSI: American National Standards Institute.
- 1.3.3 ASTM: American Society for Testing and Materials.
- 1.3.4 EIA: Electronic Industries Alliance.
- 1.3.5 TIA: Telecommunications Industry Association.
- 1.3.6 cULus: Listed by Underwriters Laboratories based on both Canadian and US (United States) standards requirements.

1.4 SUBMITTALS

- 1.4.1 Submit product data on non-continuous cable support devices, including attachment methods. Product data to include, but not limited to materials, finishes, approvals, load ratings, and dimensional information.

1.5 QUALITY ASSURANCE

- 1.5.1 Non-continuous cable supports and cable support assemblies shall be listed by Underwriters Laboratories for both Canadian and US standards (cULus).
 - 1.5.2 Non-continuous cable supports shall have the manufacturers name and part number stamped on the part for identification.
 - 1.5.3 Manufacturer: Company specializing in manufacturing products specified in this section with a minimum of five years documented experience in the industry, and certified ISO 9000.
-

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 ERICO, Inc.
- 2.1.2 Approved equal.

2.2 REFERENCES

- 2.2.1 ASTM B633 Standard Specification for Electro-deposited Coatings of Zinc on Iron and Steel
- 2.2.2 ASTM B 695-90 Standard Specification for coatings of Zinc Mechanically Deposited on Iron and Steel
- 2.2.3 ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- 2.2.4 ASTM A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
- 2.2.5 ASTM A109 Standard Specification for Steel, Strip, Carbon, Cold-Rolled
- 2.2.6 ASTM A167 Standard Specification for Stainless and heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- 2.2.7 ASTM A480/A480M Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- 2.2.8 ASTM A568 Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy Hot-Rolled and Cold-Rolled
- 2.2.9 A653 G60-Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-coated (Galvannealed) by the Hot-Dip process
- 2.2.10 ASTM A666 Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
- 2.2.11 ASTM A682 Standard Specification for Steel, Strip, High-Carbon, Cold-Rolled, Spring Quality
- 2.2.12 ASTM A879 Standard Specification for Steel Sheet, Zinc Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface
- 2.2.13 ASTM B117 Standard Method of Salt Spray (Fog) Testing
- 2.2.14 ASTM D610 Standard test Method for Evaluating Degree of Rusting on Painted Steel Surfaces UL 2043 - Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.
- 2.2.15 ANSI/ TIA/ EIA 568 Commercial Building Telecommunications Cabling Standard, current revision level.
- 2.2.16 ANSI/ TIA/ EIA 569 Commercial Building Standard for Telecommunications Pathways and Spaces, current revision level.
- 2.2.17 NFPA 70 National Electrical Code®

2.3 NON-CONTINUOUS CABLE SUPPORT SYSTEMS

- 2.3.1 Non-continuous cable supports
 - 2.3.1.1 Non-continuous cable supports shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance cables; cULus Listed.
 - 2.3.1.2 Non-continuous cable supports shall have flared edges to prevent damage while installing cables.

- 2.3.1.3 Non-continuous cable supports sized 1 5/16" and larger shall have a cable retainer strap to provide containment of cables within the hanger. The cable retainer strap shall be removable and reusable and be suitable for use in air handling spaces.
 - 2.3.1.4 Non-continuous cable supports shall have an electro-galvanized or G60 finish and shall be rated for indoor use in non-corrosive environments.
 - 2.3.1.5 Stainless Steel non-continuous cable supports are intended for indoor and outdoor use in non-corrosive environments or where only mildly corrosive conditions apply.
 - 2.3.1.6 Non-continuous cable supports shall be ERICO CableCat™ J-hook series CAT12, CAT21, CAT32, CAT64, CAT21SS, CAT32SS, CAT64SS; CAT-CMTM Double J-Hook CAT100CM; CAT-CMTM U-hook series CAT200CMLN, CAT300CMLN; and CAT-CMTM retainer CATRT200CM, CATRT300CM or approved equal.
 - 2.3.2 Adjustable non-continuous cable support sling
 - 2.3.2.1 Constructed from steel and woven laminate; sling length can be adjusted to hold up to 425 4-pair UTP; rated for indoor use in non-corrosive environments. Rated to support Category 5 and higher cable, or optical fiber cable; cULus Listed.
 - 2.3.2.2 Adjustable non-continuous cable support sling shall have a static load limit of 100 lbs.
 - 2.3.2.3 Adjustable non-continuous cable support sling shall be suitable for use in air handling spaces.
 - 2.3.2.4 If required, assemble to manufacturer recommended specialty fasteners including beam clips, flange clips, C and Z purlin clips.
 - 2.3.2.5 Acceptable products: ERICO CADDY CableCat™ CAT425; or approved equal.
 - 2.3.3 Multi-tiered non-continuous cable support assemblies
 - 2.3.3.1 Multi-tiered non-continuous cable support assemblies shall be used where separate cabling compartments are required. Assemblies may be factory assembled or assembled from pre-packaged kits. Assemblies shall consist of a steel angled hanger bracket holding up to six non-continuous cable supports, rated for indoor use in non-corrosive environments; cULus Listed.
 - 2.3.3.2 If required, the multi-tier support bracket may be assembled to manufacturer recommended specialty fasteners including beam clamps, flange clips, C and Z purlin clips.
 - 2.3.3.3 The multi-tiered support bracket shall consist of ERICO CADDY CATHBA and CableCat™ J-Hooks with screws; or approved equal.
 - 2.3.4 Non-continuous cable support assemblies from tee bar
 - 2.3.4.1 Tee bar support bracket with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.
 - 2.3.4.2 Acceptable products: ERICO CADDY CAT12TS, CAT21528, CAT32528; or approved equal.
 - 2.3.5 Non-continuous cable support assemblies from drop wire/ceiling
 - 2.3.5.1 Fastener to wire/rod with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.
 - 2.3.5.2 Acceptable products: ERICO CADDY CAT124Z34, CAT126Z34, CAT214Z34, CAT216Z34, CAT324Z34 or CAT326Z34; or approved equal.
 - 2.3.6 Non-continuous cable support assemblies from beam, flange
 - 2.3.6.1 Fastener to beam or flange with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.
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- 2.3.6.2 Acceptable products: ERICO CableCat™ J-hook series CAT12, CAT21, CAT32, CAT64 with CADDY beam clamps and CADDY flange clips; or approved equal.
 - 2.3.7 Non-continuous cable support assemblies from C & Z Purlin
 - 2.3.7.1 Fastener to C or Z purlin with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments, cULus Listed.
 - 2.3.7.2 Acceptable products: ERICO CableCat™ J-hook series CAT12, CAT21, CAT32, CAT64 with CADDY Purlin hangers; or approved equal.
 - 2.3.8 Non-continuous cable support assemblies from wall, concrete, or joist
 - 2.3.8.1 Fastener to wall, concrete, or joist with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments, cULus Listed.
 - 2.3.8.2 Acceptable products: ERICO CableCat™ J-hook series CAT12, CAT21, CAT32, CAT64, with CADDY angle bracket; or approved equal.
 - 2.3.9 Non-continuous cable support assemblies from threaded rod
 - 2.3.9.1 Fastener to threaded rod with one non-continuous cable support, factory or jobsite assembled, rated for indoor use in non-corrosive environments, cULus Listed.
 - 2.3.9.2 The multi-tiered support bracket shall have a static load limit of 300 lbs.
 - 2.3.9.3 U-hooks and Double J-hook shall attach directly to threaded rod using standard nuts.
 - 2.3.9.4 Acceptable products: ERICO CableCat™ J-hook, CAT12, CAT21, CAT32, CAT64 with CADDY CATHBA series; CAT-CMTM Double J-hook CAT100CM, CAT-CMTM Direct mount U-hook CAT200CMLN, CAT300CMLN; or AFAB series; or approved equal.
 - 2.3.10 Raised floor non-continuous cable support assemblies
 - 2.3.10.1 Fastener to raised (access) floor pedestal with one non-continuous cable support, factory or jobsite assembled, rated for indoor use in non-corrosive environments; cULus Listed.
 - 2.3.10.2 Acceptable products: ERICO CADDY CAT12CD1B, CAT21CD1B or CAT32CD1B; CAT64CD1B; or approved equal.
 - 2.3.11 Cantilever-Mounted cable supports
 - 2.3.11.1 U-hook shall be able to be assembled to a wide variety of wall mount brackets.
 - 2.3.11.2 Spacing of individual U-hooks as needed, max of 4' to 5' apart.
 - 2.3.11.3 U-hooks may have the optional attachment of a cable roller for ease in pulling cables.
 - 2.3.11.4 Acceptable products: ERICO CAT-CMTM U-hooks CAT200CMLN, CAT300CMLN; CAT-CM roller assemblies CATRL200CM, CATRL300CM; CATWMCM bracket; or approved equal.
 - 2.3.12 Installation accessories for non-continuous cable supports
 - 2.3.12.1 Cable Pulley
 - (1) Non-continuous cable supports may be used as an installation tool when a removable pulley assembly is included. The pulley shall be made of plastic and be without sharp edges. The pin and bail assembly must be able to be secured to the J-Hook during cable installation. The pulley must remain secured while cables are being pulled.
 - (2) The pin and roller assembly must be removed after cables are installed.
 - (3) Acceptable products: ERICO CADDY CAT32PLR, CAT64PLR, or approved equal.
 - 2.3.12.2 Cable Protector
-

- (1) The protective steel tube shall fit over threaded rod and be at least 4" in length.
- (2) The tube shall prevent damage to cables placed in or pulled through CAT-CMTM U-hooks. The tube shall not inhibit the pulling of cables.
- (3) Acceptable products: ERICO CAT-CMTM CATTBCM, or approved equal.

2.4 FINISHES

- 2.4.1 ASTM B633 Standard Specification for Electro-deposited Coatings of Zinc on Iron and Steel
- 2.4.2 ASTM B 695 Standard Specification for coatings of Zinc Mechanically Deposited on Iron and Steel
- 2.4.3 ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- 2.4.4 ASTM A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
- 2.4.5 Non-continuous cable supports used where only mildly corrosive conditions apply shall be stainless steel, AISI type 304.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Installation and configuration shall conform to the requirements of the current revision levels of ANSI/ EIA/TIA Standards 568 & 569, NFPA 70 (National Electrical Code), applicable local codes, and to the manufacturer's installation instructions.
- 3.1.2 Install cables using techniques, practices, and methods that are consistent with Category 5 or higher requirements and that supports Category 5 or higher performance of completed and linked signal paths, end to end.
- 3.1.3 Install cables without damaging conductors, shield, or jacket.
- 3.1.4 Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer.
- 3.1.5 Pull cables without exceeding cable manufacturer's recommended pulling tensions. Use pulling means that will not damage media.
- 3.1.6 Do not exceed load ratings specified by manufacturer.
- 3.1.7 Adjustable non-continuous support sling shall have a static load limit of 100 lbs.
- 3.1.8 Follow manufacturer's recommendations for allowable fill capacity for each size non-continuous cable support.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Cable trays, including ladder rack, wire mesh, optical fibre trough, and accessories.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 26 – Grounding and Bonding for Electrical Systems.
- 1.2.2 Section 26 05 29 – Hangers and Supports for Electrical Systems.

1.3 REFERENCES

- 1.3.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
- 1.3.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.3.3 CSA C22.2 No. 126.1-17 (CSA/NEMA) - Metal Cable Tray Systems (Binational standard with NEMA VE 1-2017).

1.4 ACTION SUBMITTALS

- 1.4.1 Product Data: Provide data for fittings and accessories.
- 1.4.2 Shop Drawings: Indicate tray type, dimensions, support points, and finishes.

1.5 INFORMATIONAL SUBMITTALS

- 1.5.1 Manufacturer's Instructions:
 - 1.5.1.1 Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements.
 - 1.5.1.2 Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 Project Record Documents: Record actual routing of cable tray and locations of supports.

1.7 REGULATORY REQUIREMENTS

- 1.7.1 Products: Listed and classified by CSA (Canadian Standards Association as suitable for the purpose specified and indicated.

2 PRODUCTS

2.1 LADDER RACK-TYPE CABLE TRAY

- 2.1.1 Description: CSA 22.2 No. 126.1, Class ladder type tray.
 - 2.1.2 Material: Aluminum.
 - 2.1.3 Inside width: As indicated.
 - 2.1.4 Inside depth: As indicated.
 - 2.1.5 Straight section rung spacing: 152 mm (6 in) on centre.
 - 2.1.6 Inside Radius of Fittings: As indicated.
 - 2.1.7 Unless otherwise noted, provide manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
 - 2.1.8 Refer to drawings for details.
 - 2.1.9 Manufacturers:
 - 2.1.9.1 Hubbell Nextframe Ladder Rack.
-

- 2.1.9.2 Canadian Electrical Raceways "Telecom Cable Rack".
- 2.1.9.3 Approved equal.

2.2 WIRE BASKET CABLE TRAY

- 2.2.1 Description: CSA 22.2 No. 126.1, Class Basket type tray.
- 2.2.2 Material: Carbon Steel, Hot Dipped Galvanized to ASTM A 123.
- 2.2.3 Inside Width: As indicated.
- 2.2.4 Inside Depth: As indicated.
- 2.2.5 Straight Section Rung Spacing: refer to drawings.
- 2.2.6 Inside Radius of Fittings: As indicated.
- 2.2.7 Unless otherwise noted, provide manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
- 2.2.8 Refer to drawings for details.
- 2.2.9 Rung spacing 152 mm (6 in).
- 2.2.10 Radius for tees 305 mm (12 in) minimum. Exact size to be verified on site.
- 2.2.11 Do not employ tray elbows. Use Tees to permit future extension of tray.
- 2.2.12 Radius for the dropouts 125 mm (5 in) minimum. Exact size to be verified on site.
- 2.2.13 Manufacturers:
 - 2.2.13.1 Cablofil.
 - 2.2.13.2 Canadian Electrical Raceways Inc.
 - 2.2.13.3 Hubbell.
 - 2.2.13.4 Thomas & Betts.

2.3 OPTICAL FIBRE ROUTING SYSTEM (FIBRE TRAY)

- 2.3.1 The optical fiber routing system shall be used to route, segregate, and protect fiber optic communication cabling.
- 2.3.2 ULC Listed (UL2024A)
- 2.3.3 Size:
 - 2.3.3.1 100 mm x 100 mm (4" x 4").
 - 2.3.3.2 As otherwise indicated on drawings.
- 2.3.4 50 mm (2") minimum bend radius through-out pathway.
- 2.3.5 Impact resistant and flame-retardant material (UL94-V0 Flammability).
- 2.3.6 Color: Black.
- 2.3.7 Will include all mounting hardware, waterfalls, directional fittings, and other accessories required for installation.
- 2.3.8 Manufacturers:
 - 2.3.8.1 Panduit Fiberrunner series.
 - 2.3.8.2 ADC FiberGuide series.
 - 2.3.8.3 Commscope SpeedPRO series.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Trays to be sized to 40 per cent maximum capacity.
 - 3.1.2 Install metallic cable tray to CSA C22.1 SB-02 and C22.2 No. 126.1.
 - 3.1.3 Install fibreglass cable tray to CSA C22.1 SB-02 and C22.2 No. 126.2.
-

- 3.1.4 Support trays to Section 26 05 29. Provide supports at each connection point, at the end of each run, and at other points to maintain spacing between supports.
- 3.1.5 Use expansion connectors where required.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Firestopping through penetrations in fire rated assemblies.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 07 84 00 – Firestopping and Smoke Seals.

1.3 REFERENCES

- 1.3.1 ASTM E 84, “Surface Burning Characteristics of Building Materials”.
- 1.3.2 ASTM E 119, “Fire Tests of Building Construction and Materials”.
- 1.3.3 ASTM E 814, “Fire Tests of Penetration Firestop Systems”.
- 1.3.4 ANSI/UL263, “Fire Tests of Building Construction and Materials”.
- 1.3.5 ANSI/UL723, “Surface Burning Characteristics of Building Materials”.
- 1.3.6 ANSI/UL1479, “Fire Tests of Through Penetration Firestops”.
- 1.3.7 Underwriters Laboratories Inc. (UL) – Fire Resistance Directory

1.4 PERFORMANCE REQUIREMENTS

- 1.4.1 Fire rated pathway devices shall be the preferred product and shall be installed in all locations where frequent cable moves, add-ons and changes will occur, such devices shall:
 - 1.4.1.1 Meet the hourly rating of the floor or wall penetrated.
 - 1.4.1.2 Permit the allowable cable load to range from 0% to 100% visual fill thereby eliminating the need to calculate allowable fill ratios.
 - 1.4.1.3 Not require any additional action on the part of the installer to open or close the pathway device or activate the internal smoke and fire seal, such as, but not limited to:
 - (1) Opening or closing of doors.
 - (2) Twisting an inner liner.
 - (3) Removal or replacement of any material such as, but not limited to, sealant, caulk, putty, pillows, bags, foam plugs, foam blocks, or any other material.
 - 1.4.1.4 Permit multiple devices to be ganged together to increase overall cable capacity.
 - 1.4.1.5 Allow for retrofit to install around existing cables.
 - 1.4.1.6 Include an optional means to lengthen the device to facilitate installation in thicker barriers without degrading fire or smoke sealing properties or inhibiting ability of device to permit cable moves, add-ons, or changes.
 - 1.4.2 Where single cables (up to 7 mm (0.27 in) diameter) penetrate gypsum board/stud wall assemblies, a fire-rated cable grommet may be substituted. Acceptable products shall be molded from plenum-grade polymer and conform to the outer diameter of the cable forming a tight seal for fire and smoke. Additionally, acceptable products shall lock into the barrier to secure cable penetration.
 - 1.4.3 Where non- mechanical products are utilized, provide products that upon curing do no re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water, or other forms of moisture characteristic during or after construction.
-

- 1.4.4 Where it is not practical to use a mechanical device, openings within floors and walls designed to accommodate telecommunications and data cabling shall be provided with re-enterable products that do not cure or dry.
- 1.4.5 Cable trays shall terminate at each barrier and resume on the opposite side such that cables pass independently through fire-rated pathway devices. Cable tray shall be rigidly supported independent from fire-rated pathway devices on each side of barrier.

1.5 SUBMITTALS

- 1.5.1 Submit under provisions of Section 01 33 00.
- 1.5.2 Product Data: Provide manufacturer's standard catalog data for specified products demonstrating compliance with referenced standards and listing numbers of systems in which each product is to be used.
- 1.5.3 Shop Drawings: Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings.
- 1.5.4 Certificates: Product certificates signed by firestop system manufacturer certifying material compliance with applicable code and specified performance characteristics.
- 1.5.5 Installation Instructions: Submit manufacturer's printed installation instructions.

1.6 QUALITY ASSURANCE

- 1.6.1 Products/Systems: Provide firestopping systems that comply with the following requirements:
 - 1.6.1.1 Firestopping tests are performed by a qualified, testing and inspection agency. A qualified testing and inspection agency is UL, or another agency performing testing and follow-up inspection services for firestop system acceptable to authorities having jurisdiction.
 - 1.6.1.2 Firestopping products bear the classification marking of qualified testing and inspection agency.
- 1.6.2 Installer Qualifications: Experience in performing work of this section who is qualified by the firestopping manufacturer as having been provided the necessary training to install firestop products in accordance with specified requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

- 1.7.1 Delivery:
 - 1.7.1.1 Manufacturer's original, unopened, undamaged containers, identification labels intact identifying product and manufacturer, date of manufacture; lot number; shelf life, if applicable; qualified testing and inspection agency's classification marking; and mixing instruction for multicomponent products.
 - 1.7.1.2 Handle and store products according to manufacturer's recommendations published in technical materials. Leave products wrapped or otherwise protected and under clean and dry storage conditions until required for installation.
- 1.7.2 Storage and Protection:
 - 1.7.2.1 Store materials protected from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

1.8 PROJECT CONDITIONS

- 1.8.1 Do not install firestopping products when ambient or substrate temperatures are outside limitations recommended by manufacturer.
 - 1.8.2 Do not install firestopping products when substrates are wet due to rain, frost, condensation, or other causes.
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- 1.8.3 Maintain minimum temperature before, during, and for a minimum 3 days after installation of materials.
- 1.8.4 Do not use materials that contain flammable solvents.
- 1.8.5 Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.
- 1.8.6 Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.
- 1.8.7 Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Specified Technologies Inc.
200 Evans Way, Somerville, NJ 08876. Tel: (800) 992-1180, Fax: (908) 526-9623, Email: specseal@stifirestop.com, Website: www.stifirestop.com.
- 2.1.2 Substitutions: as approved by the Consultant prior to tender closing.
- 2.1.3 Single Source: Obtain firestop systems for each type of penetration and construction condition indicated only from a single manufacturer.

2.2 MATERIALS

- 2.2.1 General: Use only firestopping products that have been tested for specific fire resistance rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire rating involved for each separate instance.

2.3 FIRE RATED CABLE PATHWAYS

- 2.3.1 Steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill, the following products are acceptable:
 - 2.3.1.1 Specified Technologies Inc. (STI) EZ-PATH Fire Rated Pathway.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Before beginning installation, verify that substrate conditions previously installed under other sections are acceptable for installation of firestopping in accordance with manufacturer's installation instructions and technical information.
- 3.1.2 Surfaces shall be free of dirt, grease, oil, scale, laitance, rust, release agents, water repellants, and any other substances that may inhibit optimum adhesion.
- 3.1.3 Provide masking and temporary covering to protect adjacent surfaces.
- 3.1.4 Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- 3.2.1 General: Install through-penetration firestop systems in accordance with Performance Criteria and in accordance with the conditions of testing and classification as specified in the published design.
 - 3.2.2 Manufacturer's Instructions: Comply with manufacturer's instructions for installation of firestopping products.
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3.3 FIELD QUALITY CONTROL

- 3.3.1 Inspections: Engage qualified independent inspection agency to inspect through-penetration firestop systems.
- 3.3.2 Keep areas of work accessible until inspection by authorities having jurisdiction.
- 3.3.3 Where deficiencies are found, repair firestopping products so they comply with requirements.

3.4 ADJUSTING AND CLEANING

- 3.4.1 Remove equipment, materials, and debris, leaving area in undamaged, clean condition.
- 3.4.2 Clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling as work progresses.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Labelling and identification requirements for communications systems.

1.2 REFERENCES

- 1.2.1 ANSI/TIA/EIA-606-A – Administration Standard for Commercial Telecommunications Infrastructure.
- 1.2.2 UL 969 – Marking and Labeling Systems.

2 PRODUCTS

2.1 SUMMARY

- 2.1.1 Adhesive cable labels to meet the legibility, defacement, and adhesion requirements specified in UL 969 (Ref. D-16). In addition, the labels shall meet the general exposure requirements in UL 969 for indoor use.
- 2.1.2 Self-laminating vinyl construction cable labels with a white printing area and a clear tail that self laminates the printed area when wrapped around a cable. The clear area should be of sufficient length to wrap around the cable at least one and one-half times.
- 2.1.3 ANSI/EIA/TIA-606 for colour codes shall be followed. Labels are to be mechanically printed using a laser printer. Hand written labels will not be acceptable.

2.2 LABEL PRINTER

- 2.2.1 Thermal Transfer Printer shall print high quality, industrial labels on a wide variety of materials for electrical and network applications such as wire/cable, components, safety, and facility identification.
- 2.2.2 Laminated Adhesive Label Cassettes:
 - 2.2.2.1 For flat label applications.
 - 2.2.2.2 Polyester material.
- 2.2.3 Non-Laminated Adhesive Label Cassettes:
 - 2.2.3.1 For marking wire and cable and flat label applications.
 - 2.2.3.2 Polyester material
- 2.2.4 Example Products:
 - 2.2.4.1 Panduit LS7 series hand-held printer.
 - 2.2.4.2 Panduit LS8 series hand-held printer.

2.3 NAMEPLATES

- 2.3.1 Engraved three-layer laminated plastic, letters on contrasting background:
- 2.3.2 Rack and Cabinet ID labels: 25 mm (1") high White Text on Black Background

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Cable identification labels should appear at the following locations with the numbers indicated on the cable schedule and drawings:
 - 3.1.1.1 300 mm (12 inches) from each end of the cable – after termination.
 - 3.1.1.2 Front of patch panels.
 - 3.1.1.3 Front of IDC termination blocks.
 - 3.1.1.4 Front of workstation/communications outlet faceplates.
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- 3.1.1.5 Each end of each Telecommunications Conduit.
- 3.1.2 Fibre Optic safety labels shall appear at the following locations:
 - 3.1.2.1 Along the length of the conduit or innerduct at 3 m (10 foot) intervals.
 - 3.1.2.2 At all junction boxes
 - 3.1.2.3 At all pull boxes.
 - 3.1.2.4 On all fibre optic patch panels.
- 3.1.3 Provide 25 per cent additional labels to be left in each telecommunications room on site for future growth.
- 3.1.4 Provide two Rack/Cabinet nameplates. Mount one on the front, and one on the rear of the rack.

3.2 IDENTIFICATION CONVENTIONS

- 1.1.1 All cabling will be labelled with the closet letter, followed by a dash and the wire number (i.e. A-001 would be the first wire in closet A).
- 3.2.1 Labelling for backbone wiring will be preceded with BB followed by the wire number (i.e. BB-001 would be the first backbone).

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Section Includes
 - 1.1.1.1 This document describes the products and execution requirements related to the installation and maintenance of the IT Network cable distribution systems for wireless, workstation, voice (VoIP) and data at City of Mississauga (CoM) locations.
 - 1.1.2 Scope of Service Requirements
 - 1.1.2.1 The Contractor will be responsible for cable installations at new facilities, service work, or total re-cabling of existing sites. Installations must conform to Belden IBDN Certified System Vendor (CSV).
 - 1.1.2.2 All cables and related terminations and support shall be furnished, installed, wired, tested, labeled, and documented by the Contractor as detailed in this document.
 - 1.1.2.3 The Contractor shall have access to professional staff with an RCDD designation (Registered Communications Distribution Designer) to review drawings to ensure that they conform to the wiring standards as indicated in this Document.
 - 1.1.3 Scope of Work
 - 1.1.3.1 Supply, install and test a complete Horizontal and Riser telecommunications system as specified herein and shown on the drawings provided.
 - 1.1.3.2 The data cabling system shall comprise of the following subsystems, supplied unless noted otherwise.
 - (1) Termination of new or existing horizontal cabling on a patch panel in the network closet.
 - (2) Provision of the modular jacks and faceplates at the work area outlets.
 - (3) Electrical grounding of network rack, as per code.
 - (4) Physically secure the network rack to the floor or wall.
 - (5) Labeling and testing of all cabling systems as specified.
 - (6) Provision of all specified system documentation. (i.e. As-built drawings)
 - (7) Supply and installation of horizontal cable distribution system using J-Hooks or approved equivalent* cable supporting structure (as required) beyond conduit system already installed.
 - (8) Provide Cat 6 Modular Patch Panels for termination (new install).
 - (9) Rack and Racking accessories to be installed.
 - (10) Install UPS into base of rack.
 - 1.1.4 Work to be provided by the Contractor:
 - 1.1.4.1 Procure and install Network rack (this includes cable management and PDU). Network rack needs to be secured to the floor and properly electrically grounded.
 - 1.1.4.2 Procure and install UPS (as per CoM standard).
 - (1) For other sites, provide one (1) 1.5 kVA UPS and 1 EBM.
 - 1.1.4.3 Install all the data cabling (as per CoM standard Cat6), this includes data jacks, covers and termination at both ends. Cabling to be terminated at data jack and patch panel sides.
 - 1.1.4.4 Procure and install patch panel (both fibre and ethernet) at top of network rack.
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- 1.1.4.5 Installation of the Wi-Fi Access Points as per the design provided by Network Data Team.
- 1.1.4.6 If fibre needs to be extended from Demarc to the new network closet, work with the Owner's IT representative to plan and install.
- 1.1.4.7 Provide 2 – 30 Amp Twist Lock (L5-30R) electrical outlets in the network closet directly behind the network rack.
- 1.1.5 Work by Owner:
 - 1.1.5.1 Procure, configure, and install the Cisco network switches.
 - 1.1.5.2 Procure and preconfigure the Wi-Fi access points, and deliver the access points to site for the Contractor to install.
 - 1.1.5.3 Produce Wi-Fi heat map to display AP location and Wi-Fi coverage. This needs to be completed prior to the tender being released for bidding.
 - 1.1.5.4 Card access reader to be installed on network closet door. To be provisioned by Corporate Security's vendor of record.
 - 1.1.5.5 Procure and install patch cables on the network rack between patch panels and network switches.
 - 1.1.5.6 Project pays for any new network equipment (i.e. AP's, switches) over above the existing equipment in the building prior to the renovation. An inventory count will be completed prior to the renovation. Any net new equipment required over and above what was existing in SCCC prior to the renovation will be charged to the project.

1.2 REFERENCES

- 1.2.1 City of Mississauga – Cabling Standards v1.4, June 2023.

1.3 SUBMITTALS

- 1.3.1 Shop Drawings
 - 1.3.1.1 Provide submittals in accordance with Section 01 33 00 prior to commencing installation.
 - 1.3.1.2 Submit complete cabling system layout for the Consultant's review for data, cable routing summary and cable outlet designation. Have cabling system layout performed by accredited RCDD (Registered Communications Distribution Designer) as defined by BICSI (Building Industry Consulting Service International). The Data Cabling system will not be accepted without this submission.
 - 1.3.1.3 Documentation proving compliance to End-to-End Link Performance test, as specified in Annex E of EIA/TIA SP-2840A shall be provided prior to structured cabling being installed.
 - 1.3.1.4 Submit detailed layout drawings, including termination racks prior to commencing this installation.
 - 1.3.1.5 Manufacturer's product information documents on all components of the cabling system, including horizontal and vertical cable management systems and all auxiliary components/devices and equipment prior to commencing this installation.
 - 1.3.1.6 The following documentation shall be submitted with a following cover letter listing attachments prior to commencement of work.
 - (1) A list of personnel for the project that will include the name of the Project Manager, Site Manager(s), Lead Hands, and Installers.
 - (2) Permits and notifications as may be required for the project.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Provide manufacturer's certificate at completion of installation certifying the installation.

- 1.4.2 Prepare and submit "As-built" drawings reviewed by an RCDD.
- 1.4.3 As Built Drawings
 - 1.4.3.1 Cabling Contractor is required to provide an As-Built drawing of the cable installations for all drawings included in this specification to the Owner. All drawings to be provided to the Owner at the end of the project for any changes due to site conditions.
 - 1.4.3.2 The As-Built drawings are to include cable routes and outlet locations. Numbering, icons, and drawing conventions used shall be consistent throughout all documentation provided.
 - 1.4.3.3 Contractor shall annotate the base drawings provided by the Owner and return a hard copy (same plot size as originals) and I (one) electronic copy in Adobe Acrobat PDF format.
 - 1.4.3.4 All documentation shall be submitted to the Owner within 10 working days of the completion of the project.
- 1.4.4 Upon completion of work and prior to final acceptance, the contractor will submit to the Owner the required copies of Network Certification and Documentation in the form of manuals that will include the following:
 - 1.4.4.1 Detailed information on types of materials and equipment used and their locations including: distribution frame equipment (rack), equipment types and locations; a detailed listing of cable and outlet types and locations.
 - 1.4.4.2 Accurately and neatly recorded test results.
 - 1.4.4.3 Accurately and neatly record locations including room numbers, of all network components in list form for easy reference.
 - 1.4.4.4 Identify drawings as 'Project Record Copy' and maintain in new condition making available for inspection by Owner.
 - 1.4.4.5 Bind all items listed above in a 3-ring hard covered binder suitably labelled with the names of each site/project.

1.5 QUALITY ASSURANCE

- 1.5.1 The equipment, material and installation shall conform to the latest version of the applicable codes, standards, and regulations:
 - 1.5.1.1 ANSI/EIA/TIA 568A - Commercial Building Telecommunications Cabling.
 - 1.5.1.2 ANSJ/EIA/TIA 606 - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings (CSA T528).
 - 1.5.1.3 ANSJ/EIA/TIA 607-Commercial Building Grounding and Bonding Requirements for Telecommunications (CSA T527).
 - 1.5.1.4 ANSJ/EIA/TIA TSB 67-Performance Specification For Field Testing Of Unshielded Twisted Pair Cabling Systems.
 - 1.5.1.5 CSA C22.2 No.214 -Communication Cables.
 - 1.5.1.6 CENELEC EN 50173 -Performance Requirements for Generic Cabling Schemes.
 - 1.5.1.7 NEMA WC 63 -Performance Standard For Field Testing OD Unshielded Twisted Pair Cabling System.
 - 1.5.1.8 All UTP. (Unshielded twisted pair) products are to be produced from a single manufacturer unless otherwise stated.

1.6 WARRANTY

- 1.6.1 The structured cabling systems shall be warranted for 25 years, covering all system products manufactured and provided by the single source supplier. The warrantor shall guarantee the following:
 - 1.6.1.1 All passive system components, e.g. patch panels, UTP cable and outlet jacks are free from manufacturing defects in material or workmanship.
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- 1.6.1.2 Approved cabling systems exceed the specifications of the T1A-568A standards and ISO/IEC IS 11801, if applicable.
- 1.6.1.3 The installation exceeds attenuation and near end cross talk, loss, and bandwidth requirements TIA Bulletin TIA TSB-67 and ISO/EIC IS 11801.
- 1.6.2 General workmanship and apparatus installed under this contract shall be warranted against defects of workmanship and material for a period of one year after final acceptance of work by the Owner, unless otherwise specified. The contractor will make good any defects developed as a result of their work during such time without expense to the Owner.

2 PRODUCTS

2.1 STRUCTURED CABLING

- 2.1.1 Manufacturers
 - 2.1.1.1 Belden.
 - 2.1.1.2 No substitutions.
- 2.1.2 Data Cables
 - 2.1.2.1 For all new applications a UTP cable shall be used. This cable shall consist of #24 AWG (CAT 6) solid conductors, formed into four individually twisted pairs and enclosed in a thermoplastic jacket. The cable shall be rated CMP FT-6 Belden/CDT. Performance shall comply with the latest draft of ANSI EIA/TIA 568-A. Cat 6 Data cable jacket to be yellow in colour.
- 2.1.3 End User Outlets
 - 2.1.3.1 GigaFlex PS6+ modules jacks AX IOI 065 (White).
 - 2.1.3.2 Wall faceplates shall be provisioned accordingly for single or multi-port outlets, Belden/CDT (White).
 - 2.1.3.3 Furniture outlet adapters shall be MDVO Side Entry boxes A0645273 (White).
 - 2.1.3.4 Furniture outlet adapters to be determined for Floor Monuments. Where applicable, MDVO (Mobile Dynamic Virtual Organizations) blank inserts shall be used in empty ports in wall and furniture jacks. Blank covers to match faceplate colours.
- 2.1.4 Patch Panels
 - 2.1.4.1 482 mm, 19" Rack Mountable, 48 / 24 port, 8 position RJ45 style, High Density patch panel (Belden/CDT)
 - 2.1.4.2 Category 6 Cables - Horizontal and Riser Terminations: GigaFlex PS6+ Belden/CDT, 2U, 48 Port, Black AX101458 GigaFlex PS6+ Belden/CDT, 1U, 24 Port, Black AX101456.
 - 2.1.4.3 Pinout Termination Sequence is T-568-A.
- 2.1.5 Patch Cords
 - 2.1.5.1 To be provided by the Owner.

2.2 DISTRIBUTION RACKS AND ACCESSORIES

- 2.2.1 Manufacturers:
 - 2.2.1.1 Cable Talk.
- 2.2.2 New Communication racks to be supplied by the cabling contractor. And shall be:
 - 2.2.2.1 Mandatory:
 - (1)
 - (2) Cable Talk CTR-1977-DS-B (2-Post Rack w/ Vertical Cable Management) or approved equivalent.

- (3) Cable Talk CTR-CMS-16-B vertical cable manager or approved equivalent.
- (4) Cable Talk CTPBV-1277-SD-B 15 amp. Vertical power bar "switch disabled" or approved equivalent.

2.3 RACK MOUNTED UPS (UNINTERRUPTIBLE POWER SUPPLY)

- 2.3.1 Manufacturers:
 - 2.3.1.1 APC.
 - 2.3.1.2 No substitutions.
- 2.3.2 UPS:
 - 2.3.2.1 APC UPS unit - 1.5 kVA model UPS (SMX1500RM2UCNC).
- 2.3.3 Extended Battery Module (EBM):
 - 2.3.3.1 APC EBM unit – Extended Battery Module (SMX48RMBP2U) compatible with 1.5 kVA UPS.

2.4 WIRELESS ACCESS POINTS

- 2.4.1 Manufacturers:
 - 2.4.1.1 Cisco.
- 2.4.2 Supplied by Owner for installation by Contractor.

3 EXECUTION

3.1 EXAMINATION AND PREPARATION

- 3.1.1 Examination of building(s) and site shall be the responsibility of the Contractor.
- 3.1.2 Prior to starting the installation, the contractor shall participate in a walk-through of the project site to ensure that all precursory construction necessary for the installation of the cabling infrastructure has been completed.
- 3.1.3 Contractor shall coordinate the delivery of materials to the job site with the site manager.
- 3.1.4 Contractor shall ensure that all materials are stored properly and according to the recommendations of their manufacturer. Materials shall be stored in a manner to prevent theft and damage from weather, humidity, temperature, dirt, dust, etc.
- 3.1.5 Coordinate work with other trades as necessary.

3.2 PATHWAYS FOR COMMUNICATIONS

- 3.2.1 Conduit to Section 26 05 33.13. J-Hooks: as described in Section 27 05 29.
- 3.2.2 Cabling between cable tray/j-hooks and data outlets to be enclosed in EMT conduit.
- 3.2.3 Cables/data outlets may be enclosed in pre-finished non-metallic raceways computer labs, classrooms, etc. where indicated.
- 3.2.4 Data network cables shall be installed in cable tray. Data network cables shall not be tie-wrapped to electrical conduits, mechanical piping, etc. and shall be run as far as possible from fluorescent lighting fixtures, transformers and electrical power service conduits.

3.3 INSTALLATION

- 3.3.1 All workmanship shall be in full conformance with applicable building, electrical, and other codes, as determined by the authority having jurisdiction (AHJ).
 - 3.3.2 Products shall be installed in accordance with manufacturer's instructions.
 - 3.3.3 All materials shall be installed in a neat manner.
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- 3.3.4 Strictly adhere to all Building Industry Consulting Service International (BICSI) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.
 - 3.3.5 Contractor shall keep all foods and liquids (water, drinks, etc.) away from the installation area in designated break areas.
 - 3.3.6 Any damage to building or site caused by contractor shall be restored at contractor's expense to match the condition prior to damage. If necessary and requested by the general contractor, contractor shall provide professional services to clean or repair damage at their own expense.
 - 3.3.7 General
 - 3.3.7.1 Installation shall conform to the applicable codes and standards (as listed in PART 1 Article "Quality Assurance"), manufacturer's recommendations, and best industry practices.
 - 3.3.7.2 Grounding of each distribution rack to the communications ground bus system shall be performed by the structured cabling contractor. Mounting and fastening of the distribution rack (where applicable) to the floor shall be performed by the cable contractor.
 - 3.3.7.3 Cables shall be installed in trays and or conduits as provided by the electrical contractor.
 - 3.3.7.4 No splicing of any structured cabling will be permitted.
 - 3.3.8 UPS (Uninterruptible Power Supply)
 - 3.3.8.1 Contractor to install required UPS(s) and EBM(s) in the base of the IT Rack(s).
 - 3.3.9 Data Cables
 - 3.3.9.1 All New LAN Data cable is to be Category 6 and is to be terminated on Category 6 connecting hardware at the wall termination for each location, and rack mounted patch panels in the communication closet.
 - 3.3.9.2 Label and test all cabling as detailed in this specification.
 - 3.3.10 Horizontal Distribution System
 - 3.3.10.1 Cabling contractor to supply and install a horizontal distribution system using J-hooks or approved equivalent supporting structure, beyond provided tray/conduit, as per provided drawings.
 - 3.3.10.2 Supporting cable structure is to be installed into steel support structure or concrete above.
 - 3.3.10.3 Distribution system to be designed and installed according to consultation with the Owner.
 - 3.3.10.4 Cable distribution to be designed according to best practices and to maintain a clean ceiling space.
 - 3.3.10.5 J-Hooks distribution to be designed with cable spans not to exceed 1220 mm (4 feet) between Zone conduit and J-Hook or J-Hook to J-Hook where applicable.
 - 3.3.11 Wireless Access Point Installation
 - 3.3.11.1 Termination of cable for Access Point on SMB (Surface mount box) with 3 m (10 feet) service slack in ceiling, or secure to supporting structure (in case of no ceiling).
 - 3.3.11.2 Install Cisco access points by patching to installed SMB as per Owner's provided drawings. (Ref: Figure A).
 - (1) Cabling for Wi-Fi Access Points shall be CAT6A, Plenum rated (FT6), jacket color shall be yellow.
 - (2) Cabling for Wi-Fi Access Points shall be terminated at the end of the patch panel, separate from the data jack cables. (i.e. on a 48-port patch panel, data jacks terminated on ports #1-40, AP's terminated on ports #41-48).
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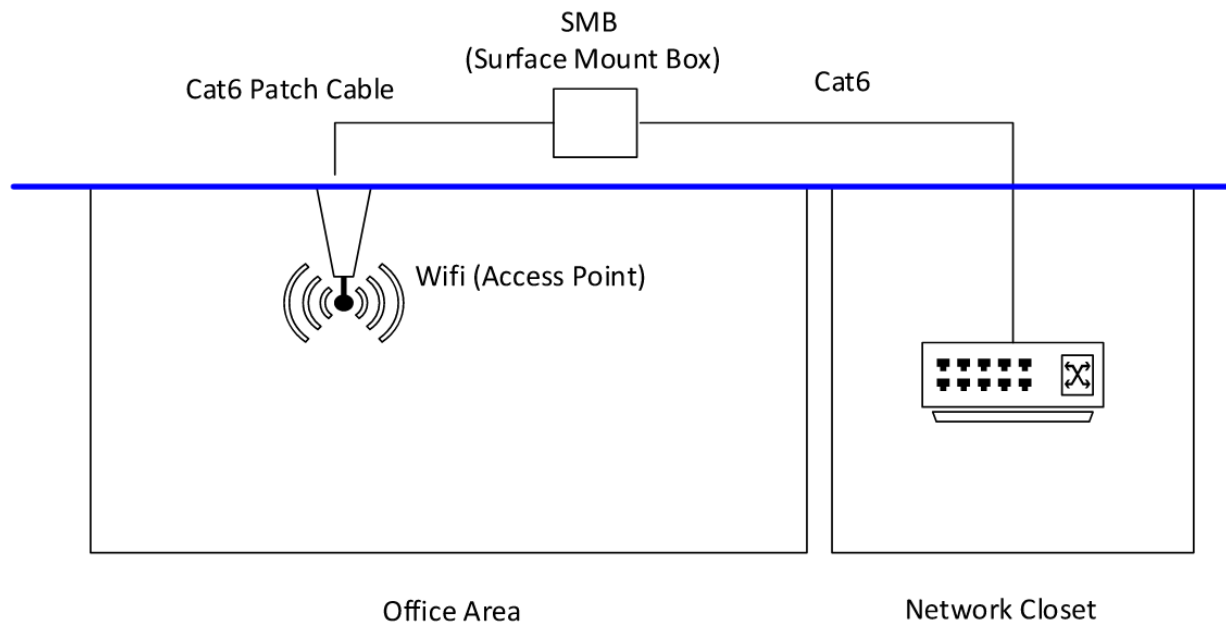


Figure A

3.4 LABELING

- 3.4.1 Provide adhesive cable labels to meet the legibility, defacement, and adhesion requirements specified in UL 969 (Ref. D 16). In addition, the labels shall meet in the general exposure requirements in UL 969 for indoor use.
- 3.4.2 Self-laminating vinyl construction cable labels with a white printing area and a clear tail that self laminates the printed area when wrapped around the cable. The clear area should be of a sufficient length to wrap around the cable at least one and a half times.
- 3.4.3 Mechanically print labels using a printer and follow guideline in ANSJ/TIA/EIA 606 for colour codes. Handwritten labels shall not be permitted.
- 3.4.4 All cables shall be labeled at the following locations:
 - 3.4.4.1 Each end of data cable lines.
 - 3.4.4.2 Front of Patch Panel- Data patch panels.
 - 3.4.4.3 Front of End User faceplates - All work area outlets.
- 3.4.5 All Data and Analog Line horizontal UTP cables shall be labeled identically using the format as shown below.
 - 3.4.5.1 **C6-XX- AAA.**
 - C6 identifies Cat 6 cable.
 - XX - identifies the floor and particular Comm. Room, where applicable (ex. 4N – floor, North side, 3W – floor 3, west side)
 - AAA identifies the incremental cable number (i.e. 001, 002, 003 etc.).

3.5 CLEANING

- 3.5.1 Upon completion of the work, remove excess debris, materials, equipment, tools, and similar items. Leave the premises clean, neat, and orderly.
- 3.5.2 Contractor shall wipe down all equipment, racks, cabinets, and sweep and ER/TR floors.

3.6 SITE TESTS AND INSPECTIONS

- 3.6.1 Testing:

- 3.6.1.1 Horizontal distribution shall be tested and certified in accordance with ANSJ/EIA/TIA and BICSI standards.
- 3.6.1.2 Copper cable testing equipment testing Cat 6 cable shall be performed in accordance with ANSI/BIA/TIA 568A standard, using level 3, Category 6 cable testers. All testing software shall be the latest version, and licensed.
- 3.6.1.3 Tests shall include Wire Map, Leogtl1, Insertion Loss (Attenuation), NEXT, (pair to pair), PSNEXT, ELFNEXT
- 3.6.1.4 (pair to pair) PSELFEXT, Return Loss, ACR, PSCAR, Propagation Delay, Delay Skew. Test results shall be recorded.
- 3.6.1.5 100% of cables must be tested. Up to 5% of test may be redone in the presence of the Owner.
- 3.6.1.6 Any failures shall be corrected expeditiously and retested. Record of test shall be submitted in both printed and soft copy. (MS Word or Excel Format only).
- 3.6.2 Testing Results:
 - 3.6.2.1 Cabling contractor shall submit test results in hard copy binder form which are to be left in the Communication closet. Electronic copies of the results are to be provided to the Owner in MS Excel, .pdf or Word format.
 - 3.6.2.2 Cabling contractor to produce a cable test summary report based on the cable schedules.
 - 3.6.2.3 The report should indicate for each cable when it was tested successfully, the result and the length.
 - 3.6.2.4 The entire report must be signed by an authorized person for the cabling contractor and the end of the project.
 - 3.6.2.5 The test result documentation must be submitted to the owner for review no later than 10 working days following the completion of the installation.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Communications conductors and cables for fire detection, suppression, and alarm systems.
- 1.1.2 Conduit for fire detection, suppression, and alarm systems.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 28 46 13 – Fire-Alarm Systems.
- 1.2.2 Section 28 46 31 – Fire-Alarm Initiating Devices.

1.3 DEFINITIONS

- 1.3.1 ULC-S524: CLASS A CIRCUIT (Return Loop Circuit) – A circuit having one continuous path connecting all components on the circuit and terminating through an alternate connection path in the source enclosure.
- 1.3.2 ULC-S524: CLASS B CIRCUIT (Terminated Circuit) – A circuit having one continuous path connecting all devices on the circuit and terminating at an end-of-line device.

1.4 REFERENCES

- 1.4.1 CSA C22.1:21, Canadian Electrical Code, Part 1 (25th Edition), Safety Standard for Electrical Installations.
- 1.4.2 Ontario Electrical Safety Code (28th edition/2021).
- 1.4.3 CSA C22.2 No. 208-14 – Fire Alarm and Signal Cable.
- 1.4.4 CAN/ULC-S139:2017 – Standard for Fire Test for Circuit Integrity of Fire-Resistive Power, Instrumentation, Control, and Data Cables.
- 1.4.5 CAN/ULC-S524-14 – Standard for the Installation of Fire Alarm Systems.

1.5 DELIVERY, STORAGE, AND HANDLING

- 1.5.1 In accordance with Section 01 60 00.

1.6 WARRANTY

- 1.6.1 All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one year from the date of acceptance.

2 PRODUCTS

2.1 CONDUIT AND WIRE FOR FIRE ALARM SYSTEM

- 2.1.1 Conduit:
 - 2.1.1.1 In accordance with Section 26 05 33.13.
 - 2.1.1.2 All wiring shall be installed in conduit or raceway.
- 2.1.2 Terminal Boxes, Junction Boxes and Cabinets:
 - 2.1.2.1 All boxes and cabinets shall be listed for their purpose and use.

2.2 FIRE ALARM CABLE

- 2.2.1 Wiring shall be in accordance with local, provincial, and national codes and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as outlined in the Ontario Electrical Safety Code, and as recommended by the fire alarm system manufacturer.
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- 2.2.2 All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signalling system, as outlined in the Ontario Electrical Safety Code.
- 2.2.3 Certified by CSA as fire alarm and signal cable type FAS 105 to CSA C22.2 No. 208.
- 2.2.4 Conductors:
 - 2.2.4.1 300 V rated multiconductor, insulated, colour coded, copper conductor.
 - (1) Use solid conductors unless noted otherwise.
 - (2) Use stranded conductors for connections between closest junction box and vibrating equipment i.e. generator set supervisory connection.
 - 2.2.4.2 Minimum 16 AWG for initiation circuits.
 - 2.2.4.3 Minimum 12 AWG for strobe signal circuits.
 - 2.2.4.4 Minimum 14 AWG for horn signal circuits.
 - 2.2.4.5 Minimum 12 AWG for bell signal circuits.
- 2.2.5 Non-Fire rated cable:
 - 2.2.5.1 Insulation: 105°C flame retardant PVC.
 - 2.2.5.2 Outer Jacket: 105°C flame retardant PVC Red.
 - 2.2.5.3 Armour: Interlocking aluminum without overall Jacket. For drops to devices in suspended ceilings from conduit system.
- 2.2.6 Fire rated fire alarm cable:
 - 2.2.6.1 Pentair Pyrotex 1850 series mineral insulated (MI) cable with 2 hour fire rating to ULC S139 and to meet Ontario Building Code Rule 3.2.7.10.
 - 2.2.6.2 Substitution: VITALink CIC Type FAS105, manufactured by Comtran (listed by ULC under ULC category code 'FHIT7' and 'FHJR7', dated 19 May 2015), installed in EMT conduit.
 - 2.2.6.3 Substitutions such as "Lifeline" installed in conduit may only be considered if listed by ULC under ULC Category Code 'FHIT7'.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect smoke detectors from contamination and physical damage.
- 3.1.2 The entire system shall be installed in accordance with the latest edition of CAN/ULC-S524 and the approved manufacturer's manuals and wiring diagrams.
- 3.1.3 The contractor shall furnish all labour, conduit, wiring, outlet boxes, junction boxes, cabinets, and similar devices necessary for installation of system devices.
- 3.1.4 Provide all necessary power supply, interconnecting and remote signal wire in dedicated conduit throughout and installed in accordance with the manufacturer's wiring diagrams and the requirements of the Ontario Electrical Safety Code and the Inspection Authority.
- 3.1.5 All penetration of floor slabs and fire walls shall be fire stopped in accordance with all local fire codes.
- 3.1.6 Install all wiring in metal raceways.
- 3.1.7 Provide wiring suitable for fire alarm circuits.
 - 3.1.7.1 Class A wiring for initiating circuits.
 - 3.1.7.2 Class B wiring for signalling circuits.
- 3.1.8 Fire rated conductors:

- 3.1.8.1 Install fire rated conductors in accordance with the manufacturer's installation guidelines.
- 3.1.8.2 Install 2 hour fire rated cables for fire alarm circuits as required by the building code where transponders (data gathering panels) or annunciators are installed in a separate fire compartment from the main FACP CPU.
- 3.1.8.3 Install 2 hour fire rated cables for fire alarm system branch circuits where the transponder or DGP is not within the same storey as the first initiation, signalling, or voice communication device in the loop for that storey.
- 3.1.8.4 In lieu of fire rated cables for the above noted cases, Contractor may, when reviewed beforehand by the Consultant, install non rated conductors in be located in a service space that is separated from the remainder of the building by a fire separation that has a fire resistance rating of not less than 2 hours.

3.2 SITE TESTS AND INSPECTIONS

- 3.2.1 The manufacturer's representative shall perform an inspection of the fire alarm equipment. The inspection shall comprise an examination and test of such equipment for the following:
 - 3.2.1.1 That the type of conductors and cables installed are that designated by the specifications.
 - 3.2.1.2 That the specified equipment has been installed in accordance with the manufacturer's recommendations.
 - 3.2.1.3 That the supervisory wiring of all devices connected to a supervised circuit is operating and that the wiring has been met to the satisfaction of the inspecting officials.
- 3.2.2 Testing to be done in the presence of the local building inspector, and the local fire inspector.

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Provide commissioning of fire alarm and interconnected systems to verify that installations are in accordance with project requirements, and to ensure proper system operation.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 01 91 13 – General Commissioning Requirements.
- 1.1.1 Section 01 91 26.13 – Integrated Systems Testing of Fire Protection and Life Safety Systems.

1.3 REFERENCES

- 1.3.1 CAN/ULC-S1001-11 – Integrated Systems Testing of Fire Protection and Life Safety Systems.

1.4 SUBMITTALS

- 1.4.1 Commissioning plan.

1.5 CLOSEOUT SUBMITTALS

- 1.5.1 Final commissioning and functional test report.

1.6 QUALIFICATIONS

- 1.6.1 Commissioning Organizations:
 - 1.6.1.1 Certified member of Electrical Contractors Association of Ontario (ECAO) or Canadian Fire Alarm Association (CFAA).

2 PRODUCTS – NOT USED

3 EXECUTION

3.1 SITE TESTS AND INSPECTIONS

- 3.1.1 Perform Commissioning of integrated systems in accordance with CAN/ULC-S1001.
- 3.1.2 Follow manufacturer's recommendations for testing.
- 3.1.3 Inspect wiring connections to all devices comprising the system.
- 3.1.4 Verify supervision of wiring at every device connection to a supervised circuit.
- 3.1.5 Test operation of every device on a system to verify its function.
- 3.1.6 Examine equipment for any apparent damage or tampering that may interfere with its intended operation.
- 3.1.7 Test equipment with capabilities for field adjustment to establish that it functions as intended under the conditions prevailing at its point of installation.
- 3.1.8 Examine devices for evidence of damage or obstructions which may interfere with their operating mechanisms.
- 3.1.9 Test automatic devices by simulating an operating condition.
- 3.1.10 Wiring:
 - 3.1.10.1 Inspect every device and test to demonstrate that disconnection of the device from the circuit or malfunction of the equipment or wiring activates the required supervisory signals. Inspection shall include verification that:

- (1) Supervisory signals operate in response to open circuits, short circuits, ground faults and disconnection of plug-in components;
 - (2) Terminations of conductors entering and leaving equipment have been made;
 - (3) Circuit polarities are in accordance with the system design, where applicable.
 - 3.1.10.2 In addition, test to establish that the power supplied to any device is within its recommended operating range and that the required voltage levels are maintained and that the fusing is correct.
 - 3.1.11 Initiating Devices - Manual:
 - 3.1.11.1 Inspect manual alarm stations in consideration of the following:
 - (1) The device shall be mounted with sufficient clearance to facilitate ease of access and proper operation;
 - (2) Operate each manual alarm station, toggle switch and key switch to verify proper functions.
 - 3.1.12 Automatic heat detectors:
 - 3.1.12.1 Use a heat source reproducible in its intensity, as recommended by the manufacturer of the device, to initiate an alarm.
 - 3.1.12.2 Test equipment - Heat lamp or Air heater. DO NOT USE AN OPEN FLAME HEAT SOURCE.
 - 3.1.12.3 Apply heat source as to not damage or operate fusible disc parts.
 - 3.1.13 Automatic heat detectors - non-resettable:
 - 3.1.13.1 Test by simulating its electrical operation by jumpering the wiring points (creating a short) adjacent to its operating mechanism.
 - 3.1.14 Automatic smoke detectors - area type:
 - 3.1.14.1 Test by introducing smoke into its detecting chamber. This may consist of actual smoke from burning materials or artificially generated smoke aerosol spray as recommended by the manufacturer. The sensitivity should be noted and adjusted if necessary.
 - 3.1.15 Automatic smoke detectors:
 - 3.1.15.1 Examine the air sampling arrangements of the detectors under actual conditions of balanced air circulation by conducting a check of the field sensitivity and a check of the air velocity in accordance with the manufacturers' recommendations.
 - 3.1.15.2 Test gas to be used similar to Automatic Smoke Detector.
 - 3.1.16 Alarm signals - audible:
 - 3.1.16.1 Test on main power supply and standby power supply with the maximum expected load on the system.
 - 3.1.16.2 The audible signalling appliances shall function as intended and shall be audible throughout the building over the background noise present.
 - 3.1.16.3 Decibel recordings in each area covering 100 sq. metres shall be taken.
 - 3.1.16.4 The level of sound should usually be 15 dB above ambient noise level.
 - 3.1.17 Alarm signals - visual:
 - 3.1.17.1 The visual signal appliances shall function as intended and shall be clearly visible.
 - 3.1.18 Fire suppression supervision:
 - 1.1.1.1 Coordinate with the requirements of Section 21 13 00.
 - 1.1.1.2 Sprinkler and standpipe trade to active each sprinkler and standpipe supervisory and alarm device by operating valves and producing flows as required in
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conjunction with fire alarm technician to observe activation of flow switches, pressure switches, supervised valves, etc.

3.1.19 Annunciators, printers, and workstations:

3.1.19.1 Inspect and operate to establish that their operation in conjunction with the control equipment and other system components, is as intended. The equipment shall be inspected to ensure:

- (1) The zone of each alarm initiating device is properly indicated;
- (2) The legend is clearly visible;
- (3) Adequate voltage under local conditions is present;
- (4) Wiring connections have been made in a workmanlike manner.
- (5) Proper care must be taken to establish that each item is complete and satisfactory.

3.1.20 Standby power supplies - batteries:

3.1.20.1 Examine batteries for possible damage and consideration of the following:

- (1) The charging system functions as intended;
- (2) The installation has not resulted in the bypassing of a fuse or a similar protective device;
- (3) The installation protects the batteries from accidental or mechanical damage.
- (4) The batteries must be able to operate the fire alarm system with the charger input disconnected for one rated load cycle.

3.1.21 Control equipment and transponders:

3.1.21.1 Test to establish that they function as intended. The following examinations and tests shall be performed:

- (1) A visual and physical inspection of all cables, plug interconnections, plug-in circuit components, lamps, sockets and controls to establish that their mechanical and electrical connections and mounting are as required for intended function and, where applicable, to confirm electrical supervision;
- (2) Verification that all field wiring is terminated in a workman-like manner;
- (3) All lamps and indicators shall be tested for operation and intended function;
- (4) All keypad functions shall be tested for operation and intended function;
- (5) All control unit functions shall be operated to verify appropriate response including all software routines and programme functions are simulated;
- (6) Simulation of open circuits, short circuits and ground faults on all relevant internal circuits in order to confirm the appropriate supervisory response;

3.1.21.2 Commissioning Report:

- (1) Provide in accordance with requirements of Section 01 91 13, supplemented as specified herein.
 - (2) Report to include relevant information of the system including:
 - (3) Each system part described.
 - (4) How the system is operated.
 - (5) What functions the system performs.
 - (6) Requirements for tests and service.
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- (7) Itemization of all devices connected on the system, their general location.
- (8) The date of the performed tests.
- (9) All pertinent details of the report sheets requested.

3.1.21.3 Verification:

- (1) The Commissioning Report to be submitted to the Commissioning Manager upon completion of commissioning and will be subject to verification by the Commissioning Manager.

3.2 *SIMULATIONS OF INTERCONNECTED SYSTEMS*

- 3.2.1 Provide simulations of all interconnected systems in accordance with CAN/ULC-S1001.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Single stage addressable fire alarm systems.
- 1.1.2 System testing and verification.
- 1.1.3 Work to be done under this Section shall include furnishing of labour, materials, and equipment required for installation, testing, and putting into proper operation a complete Fire Alarm System as shown, as specified, and as otherwise required. Complete system shall be left ready for continuous and efficient satisfactory operation.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 08 71 00 – Door Hardware: additional requirements for access control devices, magnetic door holders, etc.
- 1.2.2 Section 21 13 00 – Fire-Suppression Sprinkler Systems.
- 1.2.3 Section 26 05 00 – Common Work Results for Electrical.

1.3 UNIT PRICES

- 1.3.1 Submit with Tender unit prices to provide the following. Include installation and verification in the unit price:
 - 1.3.1.1 Section 28 46 31:
 - (1) Fire detector (heat detector or smoke detector) complete with wiring and conduit, based on 10 metre distance.
 - (2) Duct type smoke detector complete with wiring and conduit on a separate zone, based on 30 metre distance.
 - 1.3.1.2 Section 28 46 31.31:
 - (1) Manual pull station, complete with wiring and conduit based on 10 metre distance.
 - 1.3.1.3 Section 28 46 31.41:
 - (1) Zone Addressable Module (ZAM).
 - 1.3.1.4 Section 28 46 41:
 - (1) Fire alarm horn complete with wiring and conduit, based on 10 metre distance.
 - (2) Combination Fire alarm horn/strobe complete with wiring and conduit, based on 10 metre distance.
 - (3) Combination speaker/strobe complete with wiring and conduit, based on 10 metre distance.
 - 1.3.1.5 Unit cost of additional conduit and wire for the above items.
 - 1.3.1.6 Wire guard for any fire alarm device.

1.4 REFERENCES

- 1.4.1 Definitions
 - 1.4.1.1 FACP: Fire Alarm Control Panel. This is the central component of a fire alarm/detection/communication system and consists of a control panel(s) and contains the system power supply, system CPU, circuit terminations, and system annunciation functions.
 - 1.4.1.2 INITIATION DEVICE: Examples are smoke detectors, heat detectors, water flow switches, valve tamper switches, and manual pull stations. These are devices which initiate a signal and send it to the FACP telling it that an
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- abnormal event has taken place. Data Centre extinguishing systems, kitchen hood extinguishing systems, and other special extinguishing system control panels are additional examples of initiating devices.
- 1.4.1.3 NOTIFICATION DEVICE: Examples are alarm horns, alarm speakers, and strobe lights. These devices are used to indicate through visual and audible means the existence of an abnormal event throughout all areas of the protected premises.
- 1.4.1.4 CONTROL DEVICE: Examples are electronic relays or solenoids. These devices allow the FACP to automatically take certain actions during an abnormal event. For example, the FACP may energize a relay which, in turn, shuts down an air handling unit.
- 1.4.1.5 CENTRAL PROCESSING UNIT (CPU): The central computer of a multiplex fire alarm system.
- 1.4.1.6 CONCEALED: Where used in connection with installation of piping or conduit and accessories shall mean "hidden from sight" as in shafts, furred spaces, soffits or above suspended ceilings.
- 1.4.1.7 EXPOSED: Where used in connection with installation of piping or conduit and accessories shall mean "visible" or "not concealed."
- 1.4.1.8 AHJ: Authority Having Jurisdiction.
- 1.4.1.9 LISTED: Materials or equipment included in a list published by a nationally recognized laboratory that maintains periodic inspection of production of listed equipment and materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.
- 1.4.1.10 NFPA: National Fire Protection Association.
- 1.4.1.11 CLASS A: Applies to wiring from transponder to central processing unit. The CPU will detect circuit trouble and transponder will retain the ability to transit alarm upon a single fault condition.
- 1.4.1.12 CLASS B: Applies to wiring from initiating device to transponder. A trouble signal will be transmitted to the panel upon a single fault condition.
- 1.4.1.13 TRANSPONDER: Single or multiple zone/point data collection panel used within a multiplex system.
- 1.4.1.14 UL, and ULC: Underwriters Laboratories, Inc., and Underwriters Laboratories of Canada, Inc.
- 1.4.1.15 ULC Listed: Materials or equipment listed by Underwriters Laboratories of Canada and included in the most recent edition of the UL and ULC Fire Protection Equipment Directory.
- 1.4.1.16 AHU: Air Handling Unit.
- 1.4.1.17 FM: Factory Mutual Research Corporation/Factory Mutual Engineering Association.
- 1.4.2 Reference Standards
- 1.4.2.1 The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only. The equipment and installation shall comply with the latest edition/amendment referenced code, standard, or publication.
- (1) CSA Group:
- (A) CSA C22.1:21, Canadian Electrical Code, Part 1 (25th edition), Safety Standard for Electrical Installations.
- (B) Ontario Electrical Safety Code (28th edition/2021).
- (C) CSA C22.2 No. 208-14 - Fire Alarm and Signal Cable.
- (2) Ontario Regulations:
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- (A) 2012 Ontario Building Code.
- (B) 2007 Ontario Fire Code.
- (3) Underwriters Laboratories of Canada:
 - (A) CAN/ULC-S524-14 – Standard for Installation of Fire Alarm Systems.
 - (B) CAN/ULC-S525 – Audible Signal Appliances for Fire Alarm Systems.
 - (C) CAN/ULC-S526 – Visual Signal Appliances for Fire Alarm Systems.
 - (D) CAN/ULC-S527 – Control Units for Fire Alarm Systems.
 - (E) CAN/ULC-S528 – Manual Pull Stations for Fire Alarm Systems.
 - (F) CAN/ULC-S529 – Smoke Detectors for Fire Alarm Systems.
 - (G) CAN/ULC-S530 – Heat Detectors for Fire Alarm Systems.
 - (H) CAN/ULC-S533 – Egress Door Securing and Releasing Devices.
 - (I) CAN/ULC-S536 – Inspection and Testing of Fire Alarm Systems.
 - (J) CAN/ULC-S537 – Verification of Fire Alarm Systems.
 - (K) CAN/ULC-S548 – Alarm Initiating and Supervisory Devices for Water Type Extinguishing Systems.
 - (L) CAN/ULC-S561-13 – Standard for Installation and Services for Fire Signal Receiving Centres and Systems.
 - (M) CAN/ULC-S1001-11 (R2018) - Integrated Systems Testing of Fire Protection and Life Safety Systems.
- (4) All requirements of the Authority Having Jurisdiction (AHJ).

1.4.2.2 In the case of any discrepancy between these specifications, the project drawings, and any applicable local codes, the installed Fire Alarm / Life Safety System shall comply with the most stringent requirement.

1.5 ACTION SUBMITTALS

- 1.5.1 In accordance with Section 01 33 00.
- 1.5.2 Product Data: Provide electrical characteristics and connection requirements.
- 1.5.3 Submit drawings to municipal Fire Department if required, showing annunciation devices, manual pull stations, complete wiring diagrams and annunciator details and obtain their approval.
- 1.5.4 Shop Drawings:
 - 1.5.4.1 Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 1.5.4.2 Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, and device arrangement, and clearly showing ULC certification of all components.
 - 1.5.4.3 Show annunciator layout and main control panel module layout, configurations and terminations.
 - 1.5.4.4 Floor plan layouts showing all devices.
 - 1.5.4.5 Complete riser diagram, and auxiliary functions.
 - 1.5.4.6 The supplier of the system shall prepare a complete zoning schedule and artwork layout for passive graphic to be included with submittal package.
 - 1.5.4.7 Sequence of Operation narrative and zone chart.

1.6 INFORMATIONAL SUBMITTALS

- 1.6.1 Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of products.

1.7 CLOSEOUT SUBMITTALS

- 1.7.1 Maintenance Contracts
 - 1.7.1.1 Provide service and maintenance of fire alarm system for one year from Date of Substantial Completion.
- 1.7.2 Operation and Maintenance Data
 - 1.7.2.1 Operation Data: Operating instructions.
 - 1.7.2.2 Maintenance Data: Maintenance and repair procedures.
- 1.7.3 Record Documentation
 - 1.7.3.1 Record actual locations of initiating devices, signaling appliances, and end-of-line devices.
 - 1.7.3.2 Electrical Safety Authority (ESA) inspection certificate.
 - 1.7.3.3 Fire alarm verification report.
 - 1.7.3.4 Audibility test.
 - 1.7.3.5 CAN/ULC-S1001 functional test report.
- 1.7.4 Manuals
 - 1.7.4.1 Submit complete operating and maintenance manuals listing the manufacturer's name(s) including technical data sheets (with model numbers to be used indicated).
 - 1.7.4.2 Wiring diagrams shall indicate terminals and the interconnections between the items of equipment.
 - 1.7.4.3 Provide a clear and concise description of operation which gives, in detail, the information required to properly operate the equipment.

1.8 SPARE PARTS

- 1.8.1 Supply the following additional equipment as spare parts in a proper metal enclosure sized to accept the equipment as listed herein. Label the enclosure fire alarm spare parts. Enclosure shall be placed in the same room as the FACP.
 - 1.8.1.1 Supply six keys of each type.
 - 1.8.1.2 Supply three of each type of addressable detector base, smoke detector, heat detector, and fire alarm pull station.
 - 1.8.1.3 Supply three of each type of other installed initiating, notification, or controlling devices.
 - 1.8.1.4 Supply three of each type of any special tools required for system use and maintenance.
 - 1.8.1.5 Supply three of each type of signalling device used on the project.
- 1.8.2 Provide (supply and install) an additional five of each of the following devices as directed during construction. Turn over unused surplus in addition to those devices listed above:
 - 1.8.2.1 Section 28 46 31:
 - (1) Smoke detectors.
 - 1.8.2.2 Section 28 46 41:
 - (1) Fire alarm horns.
 - (2) Combination Horn/Strobes.

1.9 QUALITY ASSURANCE

- 1.9.1 Manufacturer shall examine drawings and specifications prior to award of contract to ensure that detectors, control panels and miscellaneous devices being supplied will provide a satisfactory working installation.
 - 1.9.2 Each and all items of the fire alarm system shall be listed as the products of a single manufacturer under the appropriate category by Underwriters Laboratories of Canada and shall bear the "ULC" label.
 - 1.9.3 The fire alarm control, panel shall meet the modular listing requirements of ULC. Each subassembly of the FACP, including all printed circuit boards, shall include the appropriate ULC modular label.
 - 1.9.4 Each and all items of the fire alarm system shall be covered by a one-year parts and labour warranty covering defects resulting from faulty workmanship and materials. The warranty shall be deemed to begin on the date the system is accepted by the Project Manager on issuance of the substantial performance certificate for the project.
 - 1.9.5 Regulatory Requirements
 - 1.9.5.1 Provide products listed and classified by ULC as suitable for purpose specified and indicated.
 - 1.9.6 Qualifications of Manufacturer
 - 1.9.6.1 Equipment and materials shall be provided by an experienced reputable manufacturer to ensure proper specification adherence, final connection, test, turnover, warranty compliance, and service.
 - 1.9.6.2 The manufacturer is required to have been in the fire alarm industry (service and installation) for a minimum of ten years.
 - 1.9.6.3 The manufacturer shall have in-house engineering and project management capability consistent with the requirements of this project. Qualified and approved representatives of the system manufacturer shall perform the detailed engineering design of central and remote control equipment.
 - 1.9.6.4 International Standards Organization. The system and all components will be manufactured to ISO 9001 international Quality Management and Quality Assurance Standards.
 - 1.9.6.5 Manufacturer must have service facilities within a 50 km radius of the installation location.
 - 1.9.7 Qualifications of Installers
 - 1.9.7.1 All work performed to comply with this specification shall be carried out by and/or managed by a competent firm regularly engaged in the installation and testing of fire alarm systems for commercial buildings. Equipment manufacturer shall also be competent firms which are regularly engaged in the design, installation, testing, and servicing of fire alarm systems for this type of building.
 - 1.9.7.2 Review of cut-sheets, shop drawings, calculations and other materials submitted by the contractor shall not relieve the contractor's responsibility for full compliance with the design drawings and specification unless written approval is requested by the contractor and obtained from the Consultant for each non-complying feature. Finalized agreements for all equipment deviations from the drawings and specification shall be completed prior to award of the installation contract.
 - 1.9.7.3 For those instances where the contractor cannot conform to the drawings and specification, a proposed variance shall be submitted in writing to the Consultant at least five working days prior to the bidding date. The Consultant will respond to all proposed variances within two working days of receipt.
 - 1.9.7.4 All questions concerning interpretation of the design drawings and specification shall be submitted to the Consultant in writing no later than three working days prior to the bidding date. Requests for interpretations received after this date
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will not be answered. The Consultant will respond to all requests for interpretations in writing and will provide a summary of each request and the response to all bidding contractors. The Consultant will respond to all requests for interpretations within two working days of receipt.

- 1.9.7.5 The contractor shall utilize the services of a fire alarm equipment distributor who is a factory authorized representative and a full line stocking distributor of the equipment manufacturer and shall maintain a constant inventory of the parts typical of those used in the system installation covered under this specification.
- 1.9.7.6 The contractor and the fire alarm equipment manufacturer or distributor shall each have a minimum of 7 years of continuous experience in the design and/or installation of fire alarm systems and shall have completed a minimum of five projects of similar scope and complexity which were completed using addressable/analog systems. It is intended that these projects incorporated the same equipment, manufacturer and model number, as is being proposed for this project. To verify the qualifications, the contractor and the fire alarm equipment distributor shall submit a brief design narrative which covers at least five fire alarm systems selected for references. This narrative shall indicate the project location, approximate contract value, system size by device counts, and a functional overview. These narratives shall provide an end-user contact name and telephone number for each referenced system. Where a fire alarm equipment distributor is a branch office of a fire alarm manufacturer, the references shall be chosen from projects in which the branch office completed both the design implementation and the installation.
- 1.9.7.7 The Owner reserves the right to request documentation from the contractor with respect to any pending litigation against the contractor or any subcontractor. Further, the Owner reserves the right to review an audited financial statement of the contractor or any subcontractor for the most recently completed fiscal year.
- 1.9.7.8 The Owner reserves the right to disqualify any contractor who does not comply with all requirements of the Contractor Performance Standard of this specification.
- 1.9.7.9 Installer must be certified by the Province of Ontario as a fire alarm installer.

1.10 DELIVERY, STORAGE, AND HANDLING

- 1.10.1 In accordance with Section 01 60 00.

1.11 WARRANTY

- 1.11.1 All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one year from the date of Substantial Performance.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 All references to manufacturer's model numbers and other pertinent information herein is intended to establish minimum standards of performance, function and quality.
 - 2.1.1.1 Autocall 4100ES series.
 - 2.1.1.2 Edwards; EST4 series.
 - 2.1.1.3 Notifier by Honeywell; Onyx NFS2-640C series.
 - 2.1.1.4 Mircom; FX-4000 series.
 - 2.1.1.5 Siemens; Designo series.
 - 2.1.1.6 SimplexGrinnell by Tyco Integrated Fire & Security; 4100ES series.

- 2.1.2 All equipment and components shall be the manufacturer's current model.
- 2.1.3 The materials, appliances, equipment, and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system.
- 2.1.4 The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.
- 2.1.5 The contractor shall provide, from the acceptable manufacturer's current product lines, equipment, and components, which comply, with the requirements of these specifications.
- 2.1.6 Manufacturer is to support a 20 year product.

2.2 CONDUIT AND WIRE FOR FIRE ALARM SYSTEM

- 2.2.1 Conduit:
 - 2.2.1.1 In accordance with Section 26 05 33.13.
 - 2.2.1.2 Conduit shall be in accordance with the Electrical Safety Authority (ESA), local and provincial requirements.
 - 2.2.1.3 All wiring shall be installed in conduit or raceway.
- 2.2.2 Terminal Boxes, Junction Boxes and Cabinets:
 - 2.2.2.1 All boxes and cabinets shall be listed for their purpose and use.
- 2.2.3 Fire Alarm Cable
 - 2.2.3.1 To Section 27 15 01.19.

2.3 ADDRESSABLE FIRE ALARM SYSTEM

- 2.3.1 The system to be electrically supervised, non-coded, annunciated, single-stage, addressable fire alarm system using addressable devices.
- 2.3.2 The Central Processing Unit (CPU) uses multiplex communication techniques to receive data from and transmit data to transponders remotely located throughout facility to minimize wiring costs, simplify design, to allow economical expansion and easy retrofit.
- 2.3.3 Make provisions during detailed design for future expansion of the system.
- 2.3.4 System to be complete with a minimum of three data loops per node.
- 2.3.5 The CPU is microprocessor-based to increase system reliability, speed response to alarm conditions, and reduce cost. CPU response time to alarm conditions to be no more than four seconds, regardless of system size.
- 2.3.6 Fire alarm system will be zoned as required plus 20 per cent spares.
- 2.3.7 Basic Performance:
 - 2.3.7.1 Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
 - 2.3.7.2 Provided with an emergency power supply, i.e. batteries capable of providing supervisory power for not less than 24 hours, and immediately following, emergency power under full load for not less than two hours.

2.4 FIRE ALARM ANNUNCIATOR PANEL (FAAP) AND GRAPHIC

- 2.4.1 To Section 28 46 21.22.

2.5 ULC MONITORING TRANSMITTER

- 2.5.1 To Section 28 46 21.24.

2.6 FIRE ALARM SYSTEM ACCESSORIES

- 2.6.1 To Section 28 46 25.
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2.7 FIRE ALARM INITIATION DEVICES

- 2.7.1 Automatic Initiating Devices to Section 28 46 31.
- 2.7.2 Manual Pull Stations to Section 28 46 31 31.
- 2.7.3 Supervisory Signal devices and Sprinkler Flow Switch alarms to Section 28 46 31.41.

2.8 FIRE-ALARM SUPERVISED INTERFACE HARDWARE

- 2.8.1 Door Hardware Fire Alarm Integration to Section 28 46 51.08.
- 2.8.2 HVAC Integration to Section 28 46 51.23.

2.9 SIGNALLING DEVICES

- 2.9.1 Horns and visual signal devices (strobes) to Section 28 46 41.
 - 2.9.1.1 Strobe Frequency: maximum 5 Hz.
- 2.9.2 Programmable Electronic Sounders:
 - 2.9.2.1 Shall be flush mounted as required.
- 2.9.3 Audible/Visual Combination Devices:
 - 2.9.3.1 Shall meet the applicable requirements listed above for audibility.
 - 2.9.3.2 Shall have a built in strobe, 75 candela.
- 2.9.4 Strobe Synchronizing Modules:
 - 2.9.4.1 Synchronize strobes at 1 Hz and horns at temporal over single wire pan.

2.10 OPERATION SEQUENCE

- 2.10.1 To Section 28 46 15.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 The entire system shall be installed in accordance with the edition of CAN/ULC-S524 as adopted by the applicable legislation, and the manufacturer's manuals and wiring diagrams.
- 3.1.2 The contractor shall furnish all labour, conduit, wiring, outlet boxes, junction boxes, cabinets, and similar devices necessary for a complete, functional life safety fire alarm system.
- 3.1.3 Provide all necessary power supply, interconnecting and remote signal wire in dedicated conduit throughout and installed in accordance with the manufacturer's wiring diagrams and the requirements of the Canadian Electrical Code and the Inspection Authority.
- 3.1.4 All penetration of floor slabs and fire walls shall be fire stopped in accordance with all local fire codes.
- 3.1.5 Power supply:
 - 3.1.5.1 Connect fire alarm system power supply to a dedicated circuit.
 - 3.1.5.2 Circuit breaker(s) feeding fire alarm system to be coloured red, clearly labelled, and be locked in the ON position.
- 3.1.6 Wiring:
 - 3.1.6.1 Install all wiring in metal raceways.
 - 3.1.6.2 Provide wiring suitable for fire alarm circuits.
 - (1) Class "A" wiring for initiating circuits.
 - (2) Class "A" wiring for signalling circuits unless noted otherwise.
 - 3.1.6.3 Provide fire rated cables for fire alarm circuits as required by applicable codes and standards.

- 3.1.6.4 Provide separate signalling circuits for audible and visual devices.
- 3.1.6.5 End-of-line resistors shall be furnished as required for mounting as directed by the manufacturer on Class B circuits.
 - (1) Install EOL resistors maximum 1800 mm above finished floor in interior spaces.
- 3.1.7 Install manual pull stations at 1200 mm above finished floor.
- 3.1.8 Identification
 - 3.1.8.1 Provide lamacoid label (white text on red background) for all supporting field devices indicating function of the device.

3.2 FIELD QUALITY CONTROL

- 3.2.1 The installing contractor shall provide a qualified project superintendent for the overall management and supervision of the work.
 - 3.2.2 The project superintendent shall assure that adequate supervision is provided during all periods of installation of the fire alarm system. The project superintendent and all job site supervisors shall have a minimum of five years of continuous experience in the installation of fire alarm systems of similar scope and complexity.
 - 3.2.3 Upon completion of the installation, the installing contractor shall test all alarm initiating devices, supervisory devices, control devices and notification devices for proper response and effectiveness. Operation of all annunciating devices including the FACP, printer and remote LCD panel shall be verified. Testing shall include thorough sound level measurements of audible notification devices. These tests shall be fully documented. All testing up to the point of conducting the final acceptance tests shall be recorded using a temporary printer. The permanent printer of the system, where such has been provided, shall not be installed prior to the final acceptance tests.
 - 3.2.4 All smoke detectors shall be suitably protected against contamination up to the time of the final acceptance tests.
 - 3.2.5 An itemized test report in accordance with CAN/ULC-S524, CAN/ULC-S536, and CAN/ULC-S537 shall be submitted to the Consultant. This report shall provide complete details of the testing completed for all devices as well as circuit testing parameters. Data shall be submitted indicating the sensitivity level of all system smoke detectors.
 - 3.2.6 Following completion of a 100 per cent system functional test, the contractor shall perform a thorough acceptance test of the system at the direction of and to the satisfaction of the Owner and Consultant. This test shall not be carried out until at least 15 days after completion of all contractor's testing, modification and repairs following the original contractor's functional test and submittal of the functional testing documentation to the Consultant. The 15 day interval is also intended to be a system "burn-in" period. Any false activations of the system which occur within the burn-in period which are determined to be the result of a system fault shall result in the restart of the 15 day period.
 - 3.2.7 In the event that the acceptance test of the system results in the need for system repair or modification, the contractor shall demonstrate the operability of the system to the full satisfaction of the Owner and Consultant following the completion of repairs or modification.
 - 3.2.8 In the event that the AHJ requires a separate demonstration of the operability of the system for acceptance purposes, these additional tests shall be carried out by the Contractor without expense to the Owner.
 - 3.2.9 The contractor shall conduct an independent quality assurance review of all developed "record" drawings to assure accuracy and completeness of these drawings. Any discrepancies shall be brought to the attention of the Consultant prior to construction start.
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- 3.2.10 Only directly prior to verification, remove smoke detector protectors, and clean smoke detectors thoroughly.
- 3.2.11 Inspect and check each individual device in entire system for proper connection, supervision, and function in accordance with CAN/ULC-S537. Identify detectors, manual pull stations and signal appliances not installed within requirements of CAN/ULC-S524 in remarks column of verification report.
- 3.2.12 Obtain verification certificate and verification report from manufacturer showing each device checked, and that work has been carried out. Utilize standard verification forms similar to Canadian Fire Alarm Association (CFAA) forms.

3.3 ADJUSTING

- 3.3.1 Contractor to verify programming of room names prior to fire alarm system programming, and allow for a revision to the fire alarm system programming should the Owner or AHJ wish to revise the room names.

3.4 MONITORING

- 3.4.1 Fire alarm control panel to be located as indicated. Coordinate third party CUL Listed monitoring with Owner.

3.5 MANUFACTURER SERVICES

- 3.5.1 At the final inspection a factory trained representative of the manufacturer of the major equipment shall demonstrate that the systems function properly in every respect.
 - 3.5.2 The manufacturer's representative shall make an inspection of the fire alarm equipment, including those components necessary to the direct operation of the system such as manual stations, thermal and smoke actuated detectors and controls, whether or not manufactured by the manufacturer. The inspection shall comprise an examination and test of such equipment for the following:
 - 3.5.2.1 That the type of equipment installed is that designated by the specifications.
 - 3.5.2.2 That the wiring connections to all equipment components show that the installer undertook to have observed ULC requirements. That all products of combustion (smoke) detectors have been properly calibrated and adjustments set correctly.
 - 3.5.2.3 That the representative's equipment has been installed in accordance with the manufacturer's recommendations.
 - 3.5.2.4 That the supervisory wiring of all devices connected to a supervised circuit is operating and that the wiring, having been met to the satisfaction of the inspecting officials.
 - 3.5.3 Testing to be done in the presence of the local building inspector, and the local fire inspector.
 - 3.5.4 The manufacturer(s) of the fire alarm shall make a complete inspection of all components installed for system(s), such as manual stations, horns, and annunciators and sprinkler and standpipe valves and smoke detectors to ensure the following:
 - 3.5.4.1 That the system is complete in accordance with Specifications.
 - 3.5.4.2 That the system is connected according to ULC requirements.
 - 3.5.4.3 That the system is connected in accordance with the manufacturer's recommendations.
 - 3.5.4.4 That the regulations concerning the supervision of components have been adhered to (e.g. stations, detectors, supervised valves, bells), and are properly wired and supervised.
 - 3.5.4.5 That all valves are properly connected and displayed correctly on each annunciator.
 - 3.5.4.6 That any subsequent changes necessary to conform to the above will be carried out with technical advice supplied by the Manufacturer.
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- 3.5.4.7 That all thermal detectors, smoke detectors and manual pull stations have been operated and are in good working order.
- 3.5.4.8 That all sprinkler system and standpipe system valves have been operated and are in good working order.
- 3.5.4.9 That all annunciators correctly pin-point the origin of any fire alarm.
- 3.5.4.10 That actual smoke concentration of sufficient density, have been applied to each smoke detector to cause the detector to be set off and that the sensitivity of each smoke detector has been set.
- 3.5.4.11 That all devices are in good working order. Include for replacing any defective/damaged devices at no extra cost to Owner.
- 3.5.4.12 That signal audibility is acceptable in all areas. Submit audibility readings for every Room.

3.6 SITE TESTS AND INSPECTIONS

- 3.6.1 Provide the service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system.
- 3.6.2 All initial testing shall be in accordance with the latest issue of ULC-S537 Verification of Fire Alarm Systems standard.
- 3.6.3 Provided integrated testing of life safety systems in accordance with Section 28 08 46.
- 3.6.4 A representative of the electrical contractor shall be present to participate and assist the manufacturer representative during the course of the verification. The electrical contractor shall make good any deficiencies discovered during the verification. Verify all devices. The electrical contractor shall provide one person for assistance with the verification.
- 3.6.5 The verification report shall be submitted for approval to the Consultant.
 - 3.6.5.1 Ensure verification report uses room numbers and space descriptions that are consistent with the drawings.
- 3.6.6 On completion of the inspection the manufacturer shall supply a certificate, together with detailed inspection record sheets showing location of each device and certifying the test results per unit, confirming that the system is installed, supervised and operate in accordance with Article "System Verification".
- 3.6.7 Audibility Test:
 - 3.6.7.1 Provide audibility test of signalling devices after other systems have been commissioned to verify operation at ambient sound levels.
 - 3.6.7.2 Provide audibility test report to the Consultant.
 - 3.6.7.3 Implement varied tone to suit audibility requirements.

3.7 CLOSEOUT ACTIVITIES

- 3.7.1 The System Supplier shall schedule and present documented formalized instruction for the building owner, detailing the proper operation and maintenance of the installed System.
 - 3.7.2 The instruction shall be presented in an organized and professional manner by a person factory trained in the operation and maintenance of the equipment and who is also thoroughly familiar with the installation.
 - 3.7.3 The instruction shall cover the schedule of maintenance required by ULC and any additional maintenance recommended by the system manufacturer.
 - 3.7.4 Instruction shall be made available to the Local Municipal Fire Department if requested by the Local Authority Having Jurisdiction.
 - 3.7.5 The contractor shall provide for a minimum of three training sessions of two hours in length. At least one of these training sessions shall be carried out for key personnel prior to the system being initially placed on-line for the beginning of the burn-in period.
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- 3.7.6 Three bound copies which summarize the training instruction shall be submitted to the Owner for future reference.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Single stage addressable fire alarm system Sequence of Operation.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 28 46 13 – Fire-Alarm Systems.

1.3 CLOSEOUT SUBMITTALS

- 1.3.1 Manuals
 - 1.3.1.1 Provide a clear and concise description of operation which gives, in detail, the information required to properly operate the equipment.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 The sequence listed below is representative sequence of operation, based on typical buildings.
- 2.1.2 The Contractor shall submit a project specific sequence of operation, as part of the submittal process.

2.2 OPERATION SEQUENCES

- 2.2.1 An alarm is caused by actuation of any one of the following devices:
 - 2.2.1.1 Pulling a manual station.
 - 2.2.1.2 Operation of an automatic fire alarm detector.
 - 2.2.1.3 Operation of a sprinkler flow switch.
 - 2.2.1.4 Operation of a smoke detector.
- 2.2.2 If, in any area of the building, an alarm is caused by actuation of the aforementioned devices, the following shall occur:
 - 2.2.2.1 Signals in the building shall sound.
 - 2.2.2.2 Annunciators shall indicate exact zone where alarm originated.
- 2.2.3 The activation of a manual pull station, automatic fire detector, automatic smoke detector, or sprinkler flow switch shall initiate the following sequence of operation:
 - 2.2.3.1 Sound an alarm signal throughout building.
 - 2.2.3.2 Control panel and remote annunciators shall indicate exact location of alarm via a zoned RED LED.
 - 2.2.3.3 Fans shall be automatically turned off.
 - 2.2.3.4 Initiate alarm origin on CPU and at graphic annunciator.
 - 2.2.3.5 Display the alarm event on all annunciator panels.
 - 2.2.3.6 Actuate CPU causes evacuation signal to sound and strobes to operate.
 - 2.2.3.7 The internal audible device shall sound at the control panel.
 - 2.2.3.8 Signal transmission to external systems:
 - (1) Transmit signal to monitoring station.
 - (2) Central station shall be automatically alerted via telephone lines connected for fire alarm system.
 - (3) Transmit signal to Building Automation System.
 - (4) Transmit signal to Access Control System.
 - 2.2.3.9 Door Releases:
 - (1) All stairwell/exit doors shall unlock throughout the building.

- (2) All self-closing fire/smoke doors held open shall be released.
 - 2.2.3.10 Elevator:
 - (1) Provide elevator recall functions for primary and alternate floors and elevator power shunt trip activation for each elevator.
 - (2) Each elevator lobby smoke detector shall be complete with relay base. Provide five relays and interconnecting wiring to elevator controller for elevator recall. Coordinate requirements with elevator supplier.
 - 2.2.3.11 HVAC Shutdowns:
 - (1) Activate smoke dampers.
 - 2.2.3.12 CPU indicates trouble when any fault occurs within the system.
 - 2.2.4 Alarm:
 - 2.2.4.1 Actuate CPU causes evacuation signal to sound and strobes to operate.
 - 2.2.4.2 The internal audible device shall sound at the control panel.
 - 2.2.4.3 Signal transmission to external systems:
 - (1) Transmit signal to monitoring station.
 - (2) Transmit signal to Building Automation System.
 - (3) Transmit signal to Access Control System.
 - 2.2.4.4 Door Releases:
 - (1) All stairwell/exit doors shall unlock throughout the building.
 - (2) All self-closing fire/smoke doors held open shall be released.
 - (3) Site entrance and exit gates open.
 - 2.2.4.5 Elevator:
 - (1) Provide elevator recall functions for primary and alternate floors and elevator power shunt trip activation for each elevator.
 - (2) Each elevator lobby smoke detector shall be complete with relay base. Provide five relays and interconnecting wiring to elevator controller for elevator recall. Coordinate requirements with elevator supplier.
 - 2.2.4.6 HVAC Shutdowns:
 - (1) Shut down air supply and return air fans.
 - (2) Activate smoke dampers.
 - 2.2.5 Supervisory
 - 2.2.5.1 If, in any area of the building, supervised valves of the sprinkler, systems are operated or exhibit short or open circuits, the following shall occur:
 - (1) The annunciator shall identify, as a separate zone, the item causing the trouble signal.
 - (2) The trouble buzzer on the annunciator(s) shall sound.
 - (3) The signals in the building shall not be sounded.
 - 2.2.5.2 The activation of a sprinkler supervised valve or pressure switch shall initiate the following sequence of operation:
 - (1) The control panel and remote annunciator shall indicate exact location of activity via a zoned AMBER LED
 - (2) Activate an audible tone on the control panel and remote annunciator.
 - (3) The signals in the building shall not be sounded.
 - 2.2.6 Trouble
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- 2.2.6.1 A short, ground fault or open circuit to any fire alarm conductor, the tamper or removal of any field device or the loss of primary or standby power to any control equipment will result in the following trouble sequence of operation:
- (1) The control panel and remote annunciator shall indicate exact location of activity via a zoned YELLOW LED.
 - (2) Activate an audible tone on the control panel and remote annunciator.
 - (3) The signals in the building shall not be sounded.

3 EXECUTION – NOT USED

END OF SECTION

1 GENERAL

1.1 SUMMARY

- 1.1.1 Section Includes
 - 1.1.1.1 Fire Alarm Control Panel.
 - 1.1.1.2 Fire alarm power supplies and batteries.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 28 46 21.22 – Fire-Alarm Remote Annunciators.
- 1.2.2 Section 28 46 21.24 – Supervising Station Alarm Systems Communications Equipment.

1.3 REFERENCES

- 1.3.1 Design, manufacture, install and test fire alarm system in accordance with good industry practice and in accordance with the following Codes and Standards:
 - 1.3.1.1 CAN/ULC-S524-14 – Standard for the Installation of Fire Alarm Systems.
 - 1.3.1.2 CAN/ULC-S536-13 – Standard for the Inspection and Testing of Fire Alarm Systems.
 - 1.3.1.3 CAN/ULC-S537-13 – Standard for the Verification of Fire Alarm Systems.
 - 1.3.1.4 CAN/ULC-S527-11 – Control Units for Fire Alarm Systems.
- 1.3.2 If any of the requirements of the above Codes and Standards is in conflict with the Drawings or Specifications, the Code or Standard requirements shall govern, but in no instance shall the standards established by these Drawings and Specifications be reduced by any of the Codes and Standards listed above.

1.4 ACTION SUBMITTALS

- 1.4.1 Submit shop drawings in accordance with Section 01 33 00 and items noted below. Documentation to be project specific.
 - 1.4.1.1 Generic documentation and/or alternate or as-equal products are unacceptable.
 - 1.4.1.2 Product data for each type of system component including list of materials and Underwriters' Laboratories of Canada (ULC) listing. Product data to include technical documentation features, and/or functions, and parts list.
 - 1.4.1.3 Dimensioned drawings illustrating minimum clearances and any required access space.
 - 1.4.1.4 Point to point wiring diagrams of the entire installed system differentiating clearly between factory and field installed wiring. Identify all terminals and interconnections including conductor numbering.

1.5 INFORMATIONAL SUBMITTALS

- 1.5.1 Dimensional elevation of fire alarm control panel and mounting instructions.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 In accordance with Section 01 77 00.
 - 1.6.1.1 Operation and Maintenance Manuals: Data on each product type including all features and operating sequences for both automatic and manual operations including trouble shooting and maintenance instructions, schematic and wiring diagrams, final reviewed shop drawings, manufacturer's warranty and verification test report.
 - 1.6.1.2 Final device address list and application program listing for the system as installed at the time of acceptance.
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- 1.6.1.3 A list of all input and output points in the system with a label indicating location or use of initiating device circuit, notification appliance circuit, relay, sensor, and auxiliary control circuits.
- 1.6.1.4 System power and battery charts with performance graphs and voltage drop calculations to assure that the system will operate per the prescribed backup time periods and under all voltage conditions per ULC standards.
- 1.6.1.5 Operating instructions for control panel.
- 1.6.1.6 Installation and programming manuals covering the installed system.
- 1.6.1.7 All final and certified documentation.
- 1.6.1.8 Drawings in PDF format.
- 1.6.2 Operations and Maintenance Manuals: Submit such manuals in accordance with Division 01, and prior to completion of project, in triplicate, containing following:
 - 1.6.2.1 Actual system functional description, and sequence of operation of completed installation.
 - 1.6.2.2 Detailed maintenance instructions for control equipment and each device type, maintenance schedule in accordance with CAN/ULC-S536. Trouble shooting guide for control panels and devices.
 - 1.6.2.3 Pictorial drawing of control equipment layout, showing location of components, modules, and parts, indicating catalogue numbers.
 - 1.6.2.4 Schematic diagrams of control equipment, except modules which can be exchanged as unit and internal interconnecting cables and wires.
 - 1.6.2.5 Copy of verification certificate, verification report and warranty certificates such as for fire alarm system, batteries, ancillary devices, including battery suppliers date coding for batteries.
 - 1.6.2.6 Name, address and telephone number of service representative of manufacturer to be contacted during warranty period.
 - 1.6.2.7 Name, address and telephone number of representative responsible for future software programming changes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- 1.7.1 Keys.

1.8 QUALITY ASSURANCE

- 1.8.1 Testing Personnel Qualifications: In addition to the requirements specified in Section 01 45 00 – Quality Control, provide persons currently certified by the Canadian Fire Alarm Association (CFAA) for fire alarm system testing and verification, to supervise on-site testing and verification as specified in Part 3.
- 1.8.2 Installer Qualifications: Engage an experienced factory-authorized installer to supervise work of this Section.
- 1.8.3 Single-Source Responsibility: Obtain fire alarm components from a single source who assumes responsibility for compatibility of system components.
- 1.8.4 Compliance with Local Requirements: Comply with the applicable building code, local ordinances, and regulations, and the requirements of the authorities having jurisdiction.
- 1.8.5 Listing and Labelling: Provide fire alarm systems and components specified in this Section that are listed and labelled by ULC.

1.9 TESTING AND COMMISSIONING

- 1.9.1 Perform testing and commissioning services described herein, after fire alarm, visual and audible signalling system has been installed and pretested.
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1.10 WARRANTY

- 1.10.1 Provide a warranty for materials and workmanship, including microprocessor components and software, to be free of defects for period from date of acceptance of system by Owner in accordance with the General Conditions.
- 1.10.2 Repair response times for problems defined as routine to be addressed and corrected within 24 hours, excepting statutory holidays and weekends.
- 1.10.3 Repair response times for problems defined as major to be addressed and corrected within 4 hours, excepting statutory holidays and weekends.
- 1.10.4 Contractor to provide a recommended list of spare components and devices.
- 1.10.5 Manufacturers of the major components to provide written confirmation of full warranty, extended warranty, and service back-up in case of the failure to perform or insolvency of the successful supplier.
- 1.10.6 Maintain maintenance records for each system supplied, and must submit a monthly report containing a time and date record of all reported or detected problems, detail of corrective action taken and the cause of the problem.
- 1.10.7 At end of warranty period, perform tests described above, and in accordance to CAN/ULC-S536 annual inspection and produce a final inspection report.

2 PRODUCTS

2.1 GENERAL

- 2.1.1 The Central Processing Unit (CPU) to use multiplex communication techniques to receive data from and transmit data to transponders remotely located throughout the facility to minimize wiring costs, simplify design, to allow economical expansion and easy retrofit.
- 2.1.2 Make provisions during detailed design for future expansion of the system.
- 2.1.3 The CPU is microprocessor-based to increase system reliability, speed response to alarm conditions, and reduce cost. CPU response time to alarm conditions to be no more than four seconds, regardless of system size.
- 2.1.4 Fire alarm system will be zoned as required plus 20 per cent spares.

2.2 FIRE ALARM CONTROL PANEL

- 2.2.1 Fire Alarm Control Panel (FACP) complete with Central Processing Unit (CPU) shall be housed in a surface wall mounted cabinet with baked enamel finish, full viewing window, and hinged front door cover complete with lock and two keys.
 - 2.2.1.1 Opening cabinet door shall provide access to all operating controls, but will not expose live electrical connections.
 - 2.2.1.2 Cabinet provided with sufficient capacity to allow maximum system expansion and to house alphanumeric display.
- 2.2.2 Modules: concentrated in single central location in modular central control panel.
- 2.2.3 Control panel, with number of zones as identified on fire alarm schedule plus 20% spare capacity, shall contain the following:
 - 2.2.3.1 Reset button, LED test button, alarm signal silencing push button, ground fault indicator light, system trouble indicating light, trouble signal silencing button and annunciator trouble indicating light.
 - 2.2.3.2 Relays and control modules as required for door releases, fan shut-down, extinguishing system release, and audible alarms.
 - 2.2.3.3 Alarm receiving modules for number of zones as indicated on drawings plus provision for 20% spares. Zone modules shall be capable of handling any type of device including pull stations, smoke detectors, and heat detectors to allow

- for future changing of devices without changing modules. Each module to contain a trouble alarm indicator.
- 2.2.3.4 Power supply modules as required.
- 2.2.3.5 Signal control modules as required.
- 2.2.3.6 All modules shall have visual supervision against removal.
- 2.2.4 Ancillary functions:
 - 2.2.4.1 Each ancillary function of the fire alarm system shall have its own independent bypass switch, (i.e. fans, door holders, security locks, bells, elevator homing, BMS, monitoring, etc.). Each switch is to be clearly labeled with LED annunciation of its normal and active positions.
 - 2.2.4.2 The panel shall contain enough bypass switches with a least 3 spares to provide each special system and/or ancillary system with bypass capability.
- 2.2.5 Power supply: self-contained unit, with integral power supply, battery charger, and standby batteries. Short circuit, over voltage, and brown-out monitoring to protect powered components by automatically switching to standby batteries whenever trouble condition exists in power supply.
- 2.2.6 As a result of alarm conditions received at the FACP, the system shall have ability to automatically operate specified control points such as CAN/ULC-S561 monitoring, or stopping exhaust fans, air conditioning units, and releasing magnetically held doors or other Fire Alarm related devices.

2.3 POWER SUPPLIES

- 2.3.1 The system shall be provided with sufficient battery capacity to operate the entire system upon loss of normal AC power in a normal supervisory mode for a period of 24 hours with 2 hours of alarm operation at the end of this period. The system shall automatically transfer to battery standby upon power failure. All battery charging and recharging operations shall be automatic.
 - 2.3.2 All circuits requiring system-operating power shall be 24 VDC and shall be individually fused at the control unit or transponder.
 - 2.3.3 The incoming power to the system shall be supervised so that any power failure will be indicated at the control unit. A green "power on" LED shall be displayed continuously while incoming power is present.
 - 2.3.4 The system batteries shall be supervised so that a low battery or depleted battery condition or disconnection of the battery shall be indicated at the control unit and displayed for the specific fault type.
 - 2.3.5 The system shall support 100% of addressable devices in alarm, or operated at the same time, under both primary (AC) and secondary (battery) power conditions.
 - 2.3.6 Loss of primary power shall annunciate a trouble signal at the FACP. FACP shall indicate when the system is operating on an alternate power supply.
 - 2.3.7 120 V, 60 Hz as primary source of power for system.
 - 2.3.8 Standby batteries: sealed, maintenance free, lead calcium sealed batteries.
 - 2.3.8.1 The batteries shall be sealed maintenance free type with expected life of ten years.
 - 2.3.8.2 Batteries shall be enclosed in a steel housing, or within the fire alarm control unit.
 - 2.3.8.3 A fully automatic battery charger shall be provided which shall be capable of restoring a dead battery's capacity per ULC standards.
 - 2.3.9 Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
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3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Install to CAN/ULC-S524.
- 3.1.2 Control Panel mounting height: arranged such that visual displays and operating controls are not less than 600 mm and not more than 1800 mm above the finished floor level.
- 3.1.3 Power to be provided by 120 VAC emergency circuit.
- 3.1.4 Label batteries with the in-service date.
- 3.1.5 Install Fire Alarm System components as follows:
 - 3.1.5.1 Install fire alarm control panel where shown on drawings.

3.2 *FIELD QUALITY CONTROL*

- 3.2.1 Verification in accordance with Section 28 46 13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Fire alarm annunciator panels.
 - 1.1.1.1 Main annunciator panel and remote LCD annunciator panels.
- 1.1.2 Firefighter entrances.
- 1.1.3 Passive graphics.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 21 13 00 – Fire-Suppression Sprinkler Systems.
- 1.2.2 Section 26 05 00 – Common Work Results for Electrical.
- 1.2.3 Section 28 46 13 – Fire-Alarm Systems.

1.3 REFERENCE STANDARDS

- 1.3.1 The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only. Comply with the latest edition/amendment referenced code, standard, or publication.
 - 1.3.1.1 Ontario Regulations
 - (1) Ontario Building Code.
 - (2) Ontario Fire Code.
 - 1.3.1.2 Underwriters Laboratories of Canada
 - (1) CAN/ULC-S524 – Installation of Fire Alarm Systems.
 - (2) CAN/ULC-S525 – Audible Signal Appliances for Fire Alarm Systems.
 - (3) CAN/ULC-S526 – Visual Signal Appliances for Fire Alarm Systems.
 - (4) CAN/ULC-S527 – Control Units for Fire Alarm Systems.
 - (5) CAN/ULC-S528 – Manual Pull Stations for Fire Alarm Systems.
 - (6) CAN/ULC-S529 – Smoke Detectors for Fire Alarm Systems.
 - (7) CAN/ULC-S530 – Heat Detectors for Fire Alarm Systems.
 - (8) CAN/ULC-S533 – Egress Door Securing and Releasing Devices.
 - (9) CAN/ULC-S536 – Inspection and Testing of Fire Alarm Systems.
 - (10) CAN/ULC-S537 – Verification of Fire Alarm Systems.
 - (11) CAN/ULC-S548 – Alarm Initiating and Supervisory Devices for Water Type Extinguishing Systems.
 - (12) ULC/ORD 693 – Central Station Fire Protective Signaling.
 - 1.3.1.3 All requirements of the Authority Having Jurisdiction (AHJ).
- 1.3.2 In the case of any discrepancy between these specifications, the project drawings, and any applicable local codes, comply with the most stringent requirement.

1.4 COORDINATION

- 1.4.1 Coordinate between all trades for inclusion of information to be included on passive graphic.

1.5 ACTION SUBMITTALS

- 1.5.1 In accordance with Section 01 33 00, and Section 28 46 13.
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1.5.2 Shop Drawings:

1.5.2.1 Annunciator:

- (1) Provide annunciator layout and system wiring diagram showing each device and wiring connection required.
- (2) Show annunciator layout and main control panel module layout, configurations, and terminations.

1.5.2.2 Passive Graphic:

- (1) Prepare a complete zoning schedule and artwork layout for each passive graphic to be included with submittal package.
- (2) Submit colour PDF (electronic submittal) using the identical colours as will be used in a temporary graphic for use during occupancy review by municipal fire inspector.
- (3) After occupancy review, incorporate comments from municipal fire inspector, and submit colour PDF (electronic submittal) using the identical colours as will be used in the final production graphic.

1.6 DELIVERY, STORAGE, AND HANDLING

1.6.1 In accordance with Section 01 60 00.

1.7 WARRANTY

1.7.1 All work performed and all material and equipment furnished to be warranted as free from defects and for a period of at least one year from the date of acceptance.

2 PRODUCTS

2.1 MANUFACTURERS

2.1.1 In accordance with Section 28 46 13.

2.2 FIRE ALARM ANNUNCIATOR PANEL (FAAP)

- 2.2.1 Annunciator panels will have an alphanumeric display for each detection device, and will identify the detection device initiating an alarm.
- 2.2.2 Annunciator panel located at the firefighter's entrance will have separate zone indication for each zone.
- 2.2.3 Install panel in a recessed enclosure with brushed aluminum finish. Coordinate exact location and dimensions with Architectural drawings.
- 2.2.4 Identify emergency exit door numbers/identifiers, and on the control panel/annunciator panel LED labels in order to identify the manual pull stations adjacent to said doors when being activated when cross referenced with the passive graphic.
 - 2.2.4.1 Coordinate with architectural plans indicating door IDs.

2.3 PASSIVE GRAPHIC DISPLAYS

- 2.3.1 Provide passive colour graphic display to be mounted adjacent to the fire alarm control panel and each annunciator panel as indicated on the drawings.
 - 2.3.1.1 Provides building and zone layout while defining zone boundaries.
 - 2.3.1.2 Visual reference of user's location within the building.
- 2.3.2 Multicoloured Passive Graphics:
 - 2.3.2.1 Plastic laminate type, on white background, framed and under plexiglass, 600 mm by 600 mm (24 inch by 24 inch) minimum size.

- 2.3.2.2 Different brilliant colours used to distinguish the various fire alarm zones and building outline from one another, silk-screened with durable acrylic-based inks on a white matte 3 mm (1/8 inch) thick acrylic sheet. Use UV protected inks to protect against fading or colour changes for life.
- 2.3.2.3 Provide a minimum of six different colours.
- 2.3.2.4 Uppercase text, minimum height of 4 mm (0.15 in).
- 2.3.2.5 Graphical display will indicate the following at minimum. Coordinate between all trades for inclusion of this information.
 - (1) "YOU ARE HERE" indicated in red (unique to each passive graphic location), and properly oriented to the viewer when standing in front of the graphic.
 - (2) Zone colours to clearly indicate the extents of all fire alarm zones.
 - (A) Define all egress corridors in a distinctive (dot) black hatch pattern.
 - (B) All enclosed stairs and elevators to be coloured yellow.
 - (3) Indicate the extents of zones served by air handling units with shut downs.
 - (4) Indicate the location of the fire alarm control panel, all annunciators, and network panels/nodes.
 - (5) Indicate the location of the ULC monitoring transmitter.
 - (6) Indicate the location and designation of sprinkler and standpipe monitoring devices.
 - (7) Indicate the location of Sprinkler Room(s), and all supervised fire protection devices. Coordinate with the fire protection trade(s) for exact locations of devices.
 - (8) Emergency exit doors with door numbers shown. These will be needed to cross reference with the annunciator panel labels for pull stations that are activated next to these doors.
 - (9) Label all Stair Letters. Designations to match Architectural drawings.
 - (10) Main gas shut off location.
- 2.3.3 Frame
 - 2.3.3.1 Extruded aluminum frame with concealed mounting hardware and concealed screws.
 - 2.3.3.2 Brushed silver finish.
 - 2.3.3.3 Concealed security mounting hardware.
 - 2.3.3.4 Frame to permit future replacement of graphic if the building or zone layouts change in future.
- 2.3.4 Allow for other requirements per the Authorities Having Jurisdiction, including the Municipal Building Inspector, and Municipal Fire Inspector.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Installation in accordance with Section 28 46 13.
 - 3.1.2 Install annunciators and passive graphics with the top no greater than 1800 mm (70 in) above finished floor.
 - 3.1.3 Install main annunciators with temporary passive graphics in the following locations:
 - 3.1.3.1 Ground floor lobby (firefighter's entrance).
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3.1.3.2 Adjacent to fire alarm control panel.

3.1.4 Install temporary passive graphic at fire alarm control panel.

3.2 SITE TESTS AND INSPECTIONS

3.2.1 Review passive graphics and annunciators with municipal fire inspector on site during occupancy review. Incorporate any comments and resubmit to the Consultant for review.

3.2.2 Include reprogramming of zone nomenclature by system manufacturer to suit municipal review comments.

3.2.3 After review by the Consultant, fabricate final passive graphics, and replace temporary graphics on site.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 ULC monitoring equipment for fire alarm systems.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 28 46 13 – Fire-Alarm Systems.

1.3 REFERENCES

- 1.3.1 CAN/ULC-S559:2020, Standard for Equipment for Fire Signal Receiving Centres and Systems.
- 1.3.2 CAN/ULC-S561:2020, Installation and Services for Fire Signal Receiving Centres and Systems.

1.4 COORDINATION

- 1.4.1 Coordinate the specific installation requirements of the fire alarm monitoring panel supplier with the fire alarm system supplier.

1.5 SUBMITTALS

- 1.5.1 In accordance with Section 01 33 00, and Section 28 46 13.

1.6 CLOSEOUT SUBMITTALS

- 1.6.1 ULC “Fire Protective Signaling Certificate” certificate indicating the monitoring company is in compliance with CAN/ULC-S561.

1.7 DELIVERY, STORAGE, AND HANDLING

- 1.1.1 In accordance with Section 01 60 00.

2 PRODUCTS

2.1 ULC FIRE ALARM MONITORING PROVIDER

- 2.1.1 Provide ULC monitoring transmitter at Communications Entrance Facility or adjacent to Fire Alarm Control Panel as indicated on the drawings.

2.2 MANUFACTURERS

- 2.2.1 Fire Monitoring of Canada (FMC).
- 2.2.2 Substitutions: none. FMC is Owner’s standard.

2.3 TRANSMITTER PANEL

- 2.3.1 The Fire alarm system shall be provided with a fire alarm monitoring panel that meets ULC-S559 and ULC-S561 requirements. DSC Fire Alarm Monitoring System or approved equivalent.
 - 2.3.2 The monitoring system shall support active communication or passive cell/IP communication.
 - 2.3.3 Monitoring panel shall be certified for active or passive ULC monitoring and operate on the local cellular LTE networks.
 - 2.3.4 Monitoring Panel shall have an LCD back lit display keypad with AC status indicator. Provide battery back-up for the monitoring panel and energize from a dedicated branch circuit. Provide a red lock-on device for the breaker.
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- 2.3.5 Monitoring shall be provided in a passive configuration to meet ULC-S561 requirements. System shall have a dedicated primary telephone line and shall not be shared with any other system in the facility. Provide Category 6 voice and data cabling in EMT conduit to the telephone demark in the telecommunications entrance facility in the IT room. Fire alarm system supplier shall be responsible to include a complete system with monitoring for two (2) years after substantial performance.
- 2.3.6 As part of the fire alarm system shop drawing submission provide information on the monitoring company and confirmation that the monitoring company meets ULC-S561 requirements.
- 2.3.7 The Monitoring System shall include cellular booster complete with lightning surge protector. Wilson Pro1050 or approved equivalent.
- 2.3.8 The Contractor is responsible for all wiring from the fire alarm panel to the monitoring panel and from the monitoring panel to the telecommunications entrance facility. Cabling shall be as per manufacturer's requirements. All cabling shall be run in conduit.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Locate monitoring transmitter adjacent to fire alarm control panel.
- 3.1.2 Provide one dedicated 15 A, 120 VAC circuit for monitoring transmitter.
- 3.1.3 Provide a junction box at the monitoring transmitter location with the fire alarm zone outputs from the Fire Alarm System to the monitoring transmitter.
- 3.1.4 Connect fire alarm system outputs to ULC monitoring transmitter.
- 3.1.5 Provide one data outlet to the ULC monitoring transmitter.
- 3.1.6 Post a copy of the ULC certificate at the location of the transmitter.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 End-of-Line Devices.
- 1.1.2 Fault Isolators.
- 1.1.3 Wire Guards.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 28 46 13 – Fire-Alarm Systems.
- 1.2.2 Section 28 46 31.31 – Fire-Alarm Manual Initiating Devices: manual pull station covers.

1.3 REFERENCES

- 1.3.1 CAN/ULC-S524-14 – Installation Standard for Fire Alarm Systems.

1.4 CLOSEOUT DOCUMENTS

- 1.4.1 As-Built Drawings: include location and zone of all End-of-Line devices.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- 1.5.1 Extra Stock Materials
 - 1.5.1.1 Provide (supply and install) an additional two of each of the following devices as directed during construction. Turn over unused surplus in addition to those devices listed above:
 - (1) Fault Isolators.
 - (2) End-of-Line devices.
 - (3) Wire guard.
- 1.5.2 Spare Parts
 - 1.5.2.1 Supply the following additional equipment as spare parts in a proper metal enclosure sized to accept the equipment as listed herein. Label the enclosure fire alarm spare parts. Enclosure shall be placed in the same room as the FACP.
 - (1) Supply three of each type of other installed initiating, notification, or controlling devices.
- 1.5.3 Tools
 - 1.5.3.1 Supply three of each type of any special tools required for system use and maintenance.

2 PRODUCTS

2.1 END OF LINE DEVICES

- 2.1.1 One watt type resistors mounted within outlet boxes separate from those for other devices at the locations indicated. Provide on the cover plate for each such device on approved nameplate, engraved "END-OF-LINE RESISTOR" or with an approved symbol. Provide red lamacoid plate with white 6 mm letters identifying zone.
 - 2.1.2 Finish of end of line device cover plates to be priced based on stainless steel finish; confirm exact finish with the Consultant during submittal review process.
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2.2 FAULT ISOLATORS

- 2.2.1 Module shall detect and isolate a short-circuited segment of a fault-tolerant loop whilst allowing the rest of the addressing circuit to function normally.

2.3 DEVICE GUARDS

- 2.3.1 Description: Welded wire mesh of size and shape for the initiation, signaling, or other device requiring protection.
 - 2.3.1.1 Factory fabricated and furnished by manufacturer of device.
 - 2.3.1.2 Finish: Paint of colour to match the protected device.
- 2.3.2 Pull station covers: as described in Section 28 46 31.31.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Installation to Section 28 46 13 and CAN/ULC-S524.
- 3.1.2 End-of-Line devices:
 - 3.1.2.1 Provide End-of-Line devices as directed by the manufacturer on Class B circuits.
 - 3.1.2.2 Install 1800 mm above finished floor in interior spaces and provide a label indicating the zone service.
 - 3.1.2.3 Installation of End-of-Line devices within other field devices: not permitted.
 - 3.1.2.4 Provide a permanent mark to identify the zone or circuit served by the End-of-Line device.
- 3.1.3 Fault Isolators:
 - 3.1.3.1 Provide fault isolators in accordance with CAN/ULC-S524.

3.2 FIELD TESTS AND INSPECTIONS

- 3.2.1 Testing and inspection to Section 28 46 13.
- 3.2.2 Verification to Section 28 46 13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Spot type smoke detectors.
- 1.1.2 Duct mounted smoke detectors.
- 1.1.3 Heat detectors.
- 1.1.4 Accessories.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 00 – Common Work Results for Electrical.
- 1.2.2 Section 28 46 13 – Fire-Alarm Systems.
- 1.2.3 Section 28 46 31.18 – Carbon Monoxide Detection Sensors.
- 1.2.4 Section 28 46 31.26 – Residential Smoke and Carbon Monoxide Alarms.

1.3 UNIT PRICES

- 1.3.1 Submit with Tender unit prices to provide the following. Include installation and verification in the unit price:
 - 1.3.1.1 Fire detector (heat detector or smoke detector) complete with wiring and conduit, based on 10 metre distance.
 - 1.3.1.2 Duct type smoke detector complete with wiring and conduit on a separate zone, based on 30 metre distance.
- 1.3.2 Unit cost of additional conduit and wire for the above items.
- 1.3.3 Wire guard for any fire alarm device.

1.4 REFERENCES

- 1.4.1 CAN/ULC-S524-14 – Installation Standard for Fire Alarm Systems.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- 1.5.1 Extra Stock Materials
 - 1.5.1.1 Provide (supply and install) an additional two of each of the following devices as directed during construction. Turn over unused surplus in addition to those devices listed below:
 - (1) Smoke detectors.
- 1.5.2 Spare Parts
 - 1.5.2.1 Supply the following additional equipment as spare parts in a proper metal enclosure sized to accept the equipment as listed herein. Label the enclosure fire alarm spare parts. Enclosure shall be placed in the same room as the FACP.
 - (1) Supply three of each:
 - (A) Addressable detector base.
 - (B) Smoke detector.
- 1.5.3 Tools
 - 1.5.3.1 Supply three of each type of any special tools required for system use and maintenance.

2 PRODUCTS

2.1 ANALYTICAL MICROPROCESSOR ADDRESSABLE DETECTORS – GENERAL

- 2.1.1 Early warning analog addressable detectors shall use state-of-the-art multi-sensor technology. Each detector shall incorporate a microprocessor capable of making alarm decisions based on fire parameter algorithms stored in the detectors head. The microprocessor shall evaluate all sensing elements simultaneously and take into account real-time environmental conditions and the duration of an event, resulting in reliable and accurate decisions that distinguish real fire conditions from unwanted deceptive nuisance alarms. Digital filters shall eliminate signal patterns that are not typical of fires. Detectors that use the control panel processor to make alarm decisions are not acceptable.
 - 2.1.2 Addressable detectors shall be capable of full digital communications using both broadcast and polling protocols. The maximum total analog loop response time for detectors shall be 750 ms. The maximum alarm response time for the system to sound an alarm shall not be more than 3-seconds regardless of the detector location or the number of detectors on the addressable loop. The analog loop controller shall support up to 250 devices including 125 modules, 125 detectors and 125 isolator bases. The analog loop must not require shielded wire and shall be capable of a total distance of 4000 feet minimum using #18 AWG twisted pair when 100 addressable detectors and 100 addressable modules are connected. The analog loop shall support up to 124 wiring T-taps.
 - 2.1.3 The analog loop controller shall be able to “map” and supervise the location of each addressable device installed on the loop. Device supervision shall be provided for any device that is missing, added or changes to the device type, alarm settings, features, location or changes to the wiring layout or detector bases. It shall be possible to display or print the device “map” from a laptop. The “map” shall indicate all devices on the addressable loop complete with the customer defined device location name, device and base type, supervision information and wiring as-built layout including all T-taps. If two devices are inadvertently switched during routine maintenance, the loop controller shall be able to identify the change and if the device types are identical, it shall automatically download environmental information specific to that device location and all programming shall remain intact for the respective location of each device. No reprogramming or manual addressing shall be required. If the device types do not match, both devices shall still provide their inherent protection, programmed functions shall respond accordingly for that device location and a trouble shall be logged on the system. The “map” shall indicate which devices have been switched, what device type was expected and what device type is actually installed in that location.
 - 2.1.4 Each detector shall have the ability to learn its environment and automatically adjust its reference value for changes in its environment. Detectors that require adjustments to their sensitivity settings months after they are installed are not acceptable. Environmental compensation shall allow each sensing element to adapt to short and long term changes caused by dirt, dust, humidity, temperature and ageing. The detector shall adjust and update its sensitivity (% obscuration) and ambient temperature baselines for each sensing element approximately six times per hour. The detector shall utilise a 4-hour rolling average of the environmental information and for verification purposes also maintain a 24-hour average of the analog values, both of which may be taken into account in the alarm decision making process.
 - 2.1.5 The detector’s on-board microprocessor shall monitor the environmental effects on its baseline and generate a “maintenance alert” message at the control panel when the detectors environmental compensation is 80% used up indicating it should be cleaned. This event shall be programmable to initiate any type of system response such as send an e-mail message to maintenance. When the environmental compensation head room is
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100% used up, a trouble condition shall latch on the system to advise that the detector requires cleaning immediately. Up to this point the detectors sensitivity shall not have been compromised. Dirty detectors that continue to be ignored will eventually post an internal device fault and will not false alarm as a result of the accumulation of dirt. Dirty detectors that false alarm if not cleaned are not acceptable.

- 2.1.6 The detector shall be capable of identifying up to 32 self-diagnostic codes including verification that the detectors reference value is within its prescribed factory and ULC limits. Sensitivity reports shall include the percent obscuration that the detectors alarm level is set at and the percentage of compensation used as a result of environmental factors (dirt, dust, humidity, etc.). This information shall be available for system maintenance and may be requested per device or generate reports based on only the detectors that require cleaning.
- 2.1.7 The early warning analog addressable detectors and the analog loop controller shall provide increased reliability and inherent survivability through intelligent analog conventional operation. Detectors shall automatically change to stand alone, conventional device operation in the event of a loop controller polling communications failure. In the analog conventional detector mode, each detector shall continue to operate using its programmed sensitivity and "learned" environmental information stored in the detector's memory at the time of communication failure. The analog loop controller shall be capable of monitoring the loop and activating a loop alarm, without communicating to the devices, if any detector reaches its alarm sensitivity threshold.
- 2.1.8 Each Signature Series device shall be capable of automatic electronic addressing and/or custom addressing without the use of DIP or rotary switches. Devices using DIP or rotary switches for addressing, either in the base or on the detector shall not be acceptable.
- 2.1.9 Each detector shall have a separate means of displaying communication and alarm status. A green LED shall flash to confirm normal status communication with the analog loop controller. A red LED shall flash to display alarm status. Both LED's on steady shall indicate an alarm in the conventional stand-alone mode status. The LEDs shall be visible through a full 360 degree viewing angle.
- 2.1.10 It shall be possible to matrix program Signature analog detectors. Responses shall be programmable based on activated detectors within the physical location to one another and/or the number of activated detectors in a programmable group or groups.
- 2.1.11 All detectors shall be compatible with all Signature Series mounting bases.

2.2 ANALOGUE SMOKE DETECTION SYSTEM

- 2.2.1 The system shall maintain the sensitivity level set, for each sensor, over time by automatically compensating for environmental factors such as dust and dirt accumulations in a smoke sensor's chamber. The smoke sensor shall be a smoke density measuring device having no self-contained set-point. The alarm decision for each sensor shall be determined by the control panel.
 - 2.2.2 The system shall automatically indicate when an individual sensor needs cleaning. When a sensor's average value reaches a predetermined value a 'Dirty Sensor' trouble condition shall be audibly and visually indicated at the control panel for the individual sensor. When 'Dirty Sensor' trouble conditions are reported the sensor's sensitivity level will not have been compromised by the dust and dirt accumulation in its chamber.
 - 2.2.3 It shall be possible for the user to obtain a report of all smoke sensors that are 'Almost Dirty' and will require cleaning in the near future Before they initiate a 'Dirty Sensor' trouble condition.
 - 2.2.4 All data transmissions, including the analogue value, between the smoke sensors and the control panel shall be digitally transmitted and incorporate parity and checksum digital data checks of each transmission. The system must verify that the proper sensor type is in the base to match the desired software configuration.
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- 2.2.5 An operator from the control panel, having a proper access level, shall have the ability to manually access and print the following information for each sensor in a report format that can be easily understood by the user:
 - 2.2.5.1 Primary Status.
 - 2.2.5.2 Device Type.
 - 2.2.5.3 Present Average Value.
 - 2.2.5.4 Present Sensitivity Selected.
 - 2.2.5.5 Highest Peak Detection Values.
 - 2.2.5.6 Sensor Chamber Status (Normal, Almost Dirty, Dirty, Excessively Dirty).
- 2.2.6 To manually control the following of each sensor:
 - 2.2.6.1 Clear Peak Detection Values.
 - 2.2.6.2 Enable or Disable the Point.
 - 2.2.6.3 Clear Verification Tally.
 - 2.2.6.4 Control a Sensor's Relay Driver Output.
- 2.2.7 It shall be possible to program the control panel to automatically change the sensitivity settings of each sensor based on time-of-day and day-of-week.
- 2.2.8 The control panel shall have the capability of programming each sensor for a two-stage function. This function allows a control function to occur when for example, a sensor programmed for 3% smoke obscuration reaches the threshold of 1.5% smoke obscuration.

2.3 INTELLIGENT PHOTOELECTRIC SMOKE DETECTORS

- 2.3.1 The detectors shall use the photoelectric (light scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analogue level of smoke density.

2.4 INTELLIGENT VERY EARLY WARNING (VEW) LASER DETECTORS

- 2.4.1 The VEW Detector shall be a laser type detector, which incorporates a laser diode and an integral lens. The photo sensor shall be activated by the scattering of smoke particles.
- 2.4.2 The detector shall have multiple sensitivity levels and be capable of detecting a minimum obscuration of 0.03%/ft. At least two separate and distinct alarm thresholds shall be capable of being monitored by the fire alarm control panel.

2.5 DETECTOR BASES – STANDARD

- 2.5.1 Mounting bases shall support all microprocessor-based detector types detailed in this specification.
- 2.5.2 Removal of the respective detector shall not affect communications with other addressable devices.
- 2.5.3 Field wiring connections shall be made to the room side of the base, so that wiring connections can be made or disconnected by the contractor without the need for remove the mounting base from the electrical box. Bases will have the option of external LED operation, Relay Base or Data Line Isolator Base.

2.6 DETECTOR BASE – RELAY

- 2.6.1 The relay base shall support all Addressable Detector types and have the following requirements:
 - 2.6.1.1 Form "C" contacts rated at 1 amp @ 30 VDC and listed for "pilot duty".
 - 2.6.1.2 The position of the contact shall be supervised.
 - 2.6.1.3 Separate power shall not be required to the relay base.
 - 2.6.1.4 The relay shall automatically de-energize when a detector is removed.
 - 2.6.1.5 The relay operation shall be exercised by the detector processor on power up.
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- 2.6.1.6 The relay shall be a bi-stable type and selectable for normally open or normally closed operation.
- 2.6.2 For added survivability, relay operation shall be controlled by the detectors microprocessor. The relay shall be capable of operation in the conventional stand-alone mode in the event communication is lost with the loop controller. Relay bases not controlled by the detector's microprocessor shall not be acceptable.

3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Installation to Section 28 46 13.

3.2 *FIELD TESTS AND INSPECTIONS*

- 3.2.1 Testing, and inspection to Section 28 46 13.
- 3.2.2 Verification to Section 28 46 13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Sensors for the detection of Carbon Monoxide (CO) gas.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 28 46 13 – Fire-Alarm Systems.
- 1.2.2 Section 28 46 31.26 – Residential Smoke and Carbon Monoxide Alarms.

1.3 REFERENCES

- 1.3.1 CSA 6.19-17 – Residential Carbon Monoxide Alarming Devices.
- 1.3.2 Ontario Building Code.
- 1.3.3 CAN/ULC-S529:2016 – Smoke Detectors for Fire Alarm Systems.

1.4 CERTIFICATIONS

- 1.4.1 The CO detector shall be ULC-S529 and CSA 6.19 as Carbon Monoxide alarm device.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 Edwards signature series “SIGA2” devices.
- 2.1.2 S-Tech.
- 2.1.3 CO detectors shall be compatible with the system in Section 28 46 13.

2.2 CARBON MONOXIDE SENSORS

- 2.2.1 The CO element shall be modular and can be replaced when the CO detector reaches end of life, so that the whole detector does not need to be replaced. Detectors that require the complete device to be replaced are not be acceptable.
 - 2.2.2 The CO detector element shall have an integral count-down timer that counts down from 6 years (expected life span of the CO detector component). The detector's processor shall monitor the CO detector component to ensure that if the CO device is out of tolerance before the 6-year time frame, the device will register a trouble condition and identify itself to the control panel.
 - 2.2.3 Devices include, SIGA2-COS, carbon monoxide detector, SIGA2-PCOS, combination Photoelectric/CO detector, SIGA2-PHCOS combination Photo/Thermal/ CO detector as well as SIGA2-HCOS combination Heat/CO detector. The combination devices shall only utilize one detector address and have the ability to separate the device types to a maximum of two different inputs from each addressable detector. It shall be possible to have the smoke detector activate the sounder base only like a smoke alarm and have the heat detector activate the general alarm condition. And if the CO sensor activates, the sounder base must sound the ISO Temporal 4 CO alarm code.
 - 2.2.4 The CO sensor in a sounder base shall be listed as a Carbon Monoxide Alarm to CSA-6.19. Addressable Carbon Monoxide (CO) Detector, EST model SIGA2-COS with audible sounder base. Provide intelligent addressable Carbon Monoxide Detector with Temporal 4 Audible Base.
 - 2.2.5 The CO detection element shall indicate a trouble condition at the FACP signaling end of life and the CO element of the detector shall be field replaceable. It shall be programmed at the main control panel as a supervisory indication and transmit a separate supervisory signal to the central station.
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- 2.2.6 Alternate product for mechanical rooms: S-Tech STCH-1000HW (hard wired alarm, wall mount), and STCH-100HWR (hard wired alarm with relay).

3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Installation to Section 28 46 13.
- 3.1.2 Install CO detectors in accordance with 2012 Ontario Building Code, section 6.2.12, and as indicated on the drawings.
 - 3.1.2.1 Dormitories.
 - 3.1.2.2 Apparatus bay.

3.2 *SITE TESTS AND INSPECTIONS*

- 3.2.1 Testing, and inspection to Section 28 46 13.
- 3.2.2 Verification to Section 28 46 13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Residential smoke alarms.
- 1.1.2 Residential smoke and carbon monoxide alarms.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 28 46 13 – Fire-Alarm Systems.
- 1.2.2 Section 28 46 31.18 – Carbon Monoxide Detection Sensors: standalone carbon monoxide detectors.

1.3 REFERENCES

- 1.3.1 CAN/CSA 6.19, "Residential Carbon Monoxide Alarming Devices".
- 1.3.2 CAN/ULC-S526, "Visible Signaling Devices for Fire Alarm and Signaling Systems, including Accessories".
- 1.3.3 CAN/ULC-S531, "Smoke Alarms".
- 1.3.4 CAN/ULC-S533, "Installation of Smoke Alarms".
- 1.3.5 NFPA 72, "National Fire Alarm and Signaling Code" as referenced by 2012 Ontario Building Code section 3.2.4.22. Smoke Alarms.
- 1.3.6 2012 Ontario Building Code.

1.4 UNIT PRICES

- 1.4.1 To Section 28 46 13.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- 1.5.1 Extra Stock Materials
 - 1.5.1.1 Provide (supply and install) an additional one of each of the following devices as directed during construction. Turn over unused surplus in addition to those devices listed below:
 - (1) Smoke alarms.
 - (2) Combination Carbon Monoxide and Smoke Alarm.
- 1.5.2 Spare Parts
 - 1.5.2.1 Supply the following additional equipment as spare parts in a proper metal enclosure sized to accept the equipment as listed herein. Label the enclosure fire alarm spare parts. Enclosure shall be placed in the same room as the FACP.
 - (1) Supply three of each:
 - (A) Smoke alarms.
 - (B) Combination Carbon Monoxide and Smoke Alarm.
- 1.5.3 Tools
 - 1.5.3.1 Supply three of each type of any special tools required for system use and maintenance.

2 PRODUCTS

2.1 MANUFACTURERS

- 2.1.1 BRK (First Alert).
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2.1.2 Kidde.

2.1.3 Fire alarm system manufacturers as noted in Section 28 46 13.

2.2 SMOKE ALARM WITH STROBE LIGHT

2.2.1 Basis of design: BRK model 7020BSLA.

2.2.2 The integrated strobe light and smoke alarm with the following features and functions:

2.2.2.1 Photoelectric smoke sensing chamber.

2.2.2.2 177 candela LED strobe light. When multiple units installed, strobe flash patterns will synchronize.

2.2.2.3 Fully screened sensing chamber to resist entry of small insects thereby reducing the probability of unwanted alarms.

2.2.2.4 Powered by 120V AC, 60 Hz and have a sealed 10-year lithium battery backup for alarm and a solid-state piezo horn rated at 85 dB at 3 m (10 ft) and be capable of self-restoring.

2.2.2.5 A visual green LED power-on indicator to confirm unit is receiving power or is in alarm.

2.2.2.6 A full function test button should check all alarm functions by simulating a smoke condition, causing the unit to alarm.

2.2.2.7 Two Latching features:

(1) Alarm Latch to easily identify initiating alarm after alarm condition has subsided.

(2) Low battery latch: to visually identify which unit is in low battery condition.

2.2.2.8 Two Silence Features:

(1) Alarm Silence to temporarily silence nuisance alarms.

(2) Low Battery Silence to silence low battery chirp for up to 8 hours.

2.2.2.9 The unit shall be capable of operating between 4 degrees C (4 degrees F) and 38 degrees C (100 degrees F) and relative humidity between 10% and 90%.

2.2.2.10 The unit shall have a plug-in connector and be capable of interconnection of up to 18 units with smoke, heat, CO alarms and relays, of which 12 can be smoke alarms.

2.2.2.11 Meet the requirements of CAN/ULC-S531 and CAN/ULC-S526.

2.3 COMBINATION SMOKE AND CARBON MONOXIDE ALARM WITH STROBE LIGHT

2.3.1 Basis of design: BRK model 7030BSLA.

2.3.2 The integrated strobe light and combination smoke and carbon monoxide alarm with the following features and functions:

2.3.2.1 Photoelectric smoke sensing chamber and electrochemical carbon monoxide sensor.

2.3.2.2 177 candela LED strobe light. The Smart Strobe shall have separate flash patterns to distinguish between smoke/heat and carbon monoxide dangers. When multiple units installed, strobe flash patterns will synchronize.

2.3.2.3 Fully screened sensing chamber to resist entry of small insects thereby reducing the probability of unwanted alarms.

2.3.2.4 Powered by 120 VAC, 60 Hz and have a sealed 10-year lithium battery backup for alarm and a solid-state piezo horn rated at 85 dB at 3 m (10 ft) and be capable of self-restoring.

2.3.2.5 A visual green LED power-on indicator to confirm unit is receiving power or is in alarm.

2.3.2.6 A full function test button should check all alarm functions.

2.3.2.7 Two Latching features:

- (1) Alarm Latch to easily identify initiating alarm after alarm condition has subsided.
 - (2) Low battery latch: to visually identify which unit is in low battery condition.
- 2.3.2.8 Two Silence Features:
 - (1) Alarm Silence to temporarily silence nuisance alarms.
 - (2) Low Battery Silence to silence low battery chirp for up to 8 hours.
- 2.3.2.9 The unit shall be capable of operating between 4 degrees C (40 degrees F) and 38 degrees C (100 degrees F) and relative humidity between 10% and 95%.
- 2.3.2.10 The unit shall have a plug-in connector and be capable of interconnection of up to 18 units with smoke, heat, CO alarms and relays, of which 12 can be smoke alarms.
- 2.3.2.11 Meet the requirements of CSA 6.19, CAN/ULC-S531 and CAN/ULC-S526.

3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Install smoke alarms in accordance with 2012 OBC 3.2.4.22., manufacturer's instructions, and to CAN/ULC-S533.
- 3.1.2 Install carbon monoxide alarms in accordance with 2012 OBC 6.2.12.
- 3.1.3 Circuit from same breaker as the washroom lighting with no disconnect switch between the overcurrent device and the smoke alarm.
- 3.1.4 Interconnect smoke alarms installed in the same dwelling unit so that the actuation of one smoke alarm will cause all smoke alarms within the dwelling unit to sound.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Intelligent Modules.
- 1.1.2 Fire Alarm Pull Stations for Single Stage Fire Alarm Systems.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 21 13 00 – Fire-Suppression Sprinkler Systems.
- 1.2.2 Section 26 05 00 – Common Work Results for Electrical.
- 1.2.3 Section 28 46 13 – Fire-Alarm Systems.

1.3 REFERENCES

- 1.3.1 CAN/ULC-S528, Manual Stations for Fire Alarm Systems.

1.4 UNIT PRICES

- 1.4.1 Submit with Tender unit prices to provide the following. Include installation and verification in the unit price:
 - 1.4.1.1 Manual pull station, complete with wiring and conduit based on 10 m (30 ft) distance.
 - 1.4.1.2 Unit cost of additional conduit and wire for the above items.
 - 1.4.1.3 Unit cost for supply and installation of pull station cover.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- 1.5.1 Extra Stock Materials
 - 1.5.1.1 Provide (supply and install) an additional three of each manual pull station to be used as directed on site during construction.
 - 1.5.1.2 Turn over unused surplus in addition to those devices listed below.
- 1.5.2 Spare Parts
 - 1.5.2.1 Supply the following additional equipment as spare parts in a proper metal enclosure sized to accept the equipment as listed herein. Label the enclosure fire alarm spare parts. Enclosure shall be placed in the same room as the FACP.
 - (1) Supply 6 keys of each type.
 - (2) Supply 3 of each type of fire alarm pull station.
 - (3) Supply 10 manual pull station break-glass rods.
- 1.5.3 Tools:
 - 1.5.3.1 Supply three of each type of any special tools required for system use and maintenance.

2 PRODUCTS

2.1 MICROPROCESSOR BASED INTELLIGENT MODULES

- 2.1.1 General
 - 2.1.1.1 Zone Addressable Modules (ZAM) shall be used for the monitoring of water flow, valve tamper, fire suppression control panels, non-addressable detectors, and for control of fans or dampers that require shutdown or manual control in an alarm condition.
 - 2.1.1.2 Monitor ZAM's shall monitor any N/O contact device and be capable of powering 2-wire smoke detectors. The ZAM will communicate the zone's status
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- (normal, alarm, trouble) to the transponder. The ZAM's zone address shall be set at the time of installation via a dip switch package.
- 2.1.1.3 Control ZAM's shall be able to provide supervised or non-supervised control of any control function. The ZAM will communicate the zone's status (normal, trouble) to the transponder. Each control ZAM shall provide a double pole double throw relay for switching loads of up to 120 VAC. Each common leg of the relay shall be equipped with a replaceable 2 Amp fuse. The ZAM's zone address shall be set at the time of installation via a dip switch package.
- 2.1.1.4 Fire Alarm / Life Safety System shall incorporate microprocessor-based addressable modules for the monitoring and control of system Input and Output functions over a 2-wire electronic communications loop, using both broadcast and serial polling protocols. All modules shall display communications and alarm status via LED indicators. The function of each connected module shall be determined by the module type, and shall be defined in the system software through the application of a personality code. All addressing of the Microprocessor-based Addressable Modules shall be done electronically, and the electrical location of each module shall be automatically reported to the Fire Alarm Control Panel, where it may be downloaded into a PC, or printed out. The addressing of the modules will not be dependent on their electrical location on the circuit. All field wiring to the Microprocessor-based Addressable Modules shall be supervised for opens and ground faults and shall be location identified to the module of incidence. Diagnostic circuitry, and their associated indicators, with reviewable Trouble Codes, shall be integral to the Microprocessor-based Addressable Modules to assist in troubleshooting system faults. Each module shall be suitable for operation in the following environment:
- (1) Temperature: 0°C to 49°C (32°F to 120°F).
 - (2) Humidity: 0-93% RH, non-condensing.
- 2.1.2 Single Input Module:
- 2.1.2.1 Microprocessor-based Addressable Modules shall be used to provide one (1) supervised Class A input circuit capable of latching operation for use with contact devices, non-damped Waterflow Switches, non-latching supervisory sprinkler switches.
- 2.1.3 Dual Input Module:
- 2.1.3.1 Microprocessor-based Addressable Modules shall be used to provide two (2) independent supervised Class A input circuits capable of operation with contact devices. Both of the input circuits shall be terminated to, and operated from, the same microprocessor-based addressable module.
- 2.1.3.2 Modules configured for water flow operation shall have an automatic delay of 15 s before reporting the water flow alarm condition to the Fire Alarm Control Panel. The module shall monitor sprinkler supervisory switches and shall automatically report the supervisory function to the Fire Alarm Control Panel each time the associated dry contact closes.
- 2.1.4 Monitor Module:
- 2.1.4.1 The Microprocessor-based Addressable Monitor Module shall be factory set to support one (1) supervised Class A Normally-Open Active Non-Latching Monitor circuit. The module shall automatically report the monitor function to the Fire Alarm Control Panel each time the associated dry contact closes.
- 2.1.5 Control Relay Module:
- 2.1.5.1 Microprocessor-based Addressable Control Relay Modules shall provide one form "C" dry relay contact rated at 2 amps at 24 VDC or 0.5 A at 120 VAC to, control external appliances or equipment processes. The control relay module
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shall be rated for pilot duty applications. The position of the relay contact shall be confirmed by the system firmware.

2.2 MICROPROCESSOR BASED ADDRESSABLE MANUAL PULL STATIONS

- 2.2.1 Addressable manual fire alarm boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key.
- 2.2.2 Stations must be designed such that after an actual activation, they cannot be restored to normal without the use of a special tool.
- 2.2.3 All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
- 2.2.4 Manual fire alarm boxes shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 44 mm (1.75 in) or larger.
- 2.2.5 All addressing of the Manual Pull Stations shall be done electronically, and the electrical location of each station shall be automatically reported to the Fire Alarm Control Panel, where it may be downloaded into a PC, or printed out. The addressing of the Manual Pull Station will not be dependent on their electrical location on the circuit.
- 2.2.6 The manual station shall be suitable for mounting on a North American 38 mm (1-1/2 inch) deep, 100 mm (4 inch) square electrical box with 13 mm (1/2 in) raised cover.
- 2.2.7 All Manual Fire Alarm station shall be suitable for operation in the following environment:
 - 2.2.7.1 Temperature: 0 degrees C to 49 degrees C (32 degrees F to 120 degrees F).
 - 2.2.7.2 Humidity: 0-93 per cent RH, non-condensing.
- 2.2.8 Pull Station Cover
 - 2.2.8.1 All Manual Fire Alarm pull stations shall be provided with a clear, tamperproof, polycarbonate shield and frame that fits over manual pull stations. When lifted to gain access to the actual alarm, it shall sound a 95 dB or 105 dB warning horn.
 - 2.2.8.2 The cover is connected to the frame by a cable. When the cover is lifted, it hangs off of the frame and the horn will sound until the cover is snapped back onto the frame (or for the life of the battery).
 - 2.2.8.3 Battery shall be provided for each cover.
- 1.1.1.1 Tamper or protecting covers for manual stations shall comply with CAN/ULC-S528, Including Accessories.
- 1.1.2 Red surface backbox
 - 1.1.2.1 Similar to Mircom BB-300, or Notifier BB series.
- 2.2.9 Pull stations shall be addressable, single action, non-coded, single stage, semi-flush mounted type.
- 2.2.10 Provide contacts for connection to magnetic locking devices power supply such that upon activation of the local pull station or first stage fire alarm signal the magnetic locks release.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Installation to Section 28 46 13.
 - 3.1.2 Install manual pull stations at 1200 mm above finished floor.
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- 3.1.3 Where possible, install the manual station on the latch side of a single door at a maximum lateral distance of 1500 mm (59 in) from the door opening.
- 3.1.4 Install manual pull stations on both sides of a series of doors exceeding 12 m (39 feet) in total width, and within 1500 mm (59 in) of each side of the opening.
- 3.1.5 When installing manual pull station on a glass partition mullion, provide red surface backbox for pull station, and fish armoured flexible cables through mullion of door frame.

3.2 SITE TESTS AND INSPECTIONS

- 3.2.1 Testing, and inspection to Section 28 46 13.
- 3.2.2 Verification to Section 28 46 13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Intelligent modules.
- 1.1.2 Sprinkler room temperature sensors.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 21 13 00 – Fire-Suppression Sprinkler Systems.
- 1.2.2 Section 26 05 00 – Common Work Results for Electrical.
- 1.2.3 Section 28 46 13 – Fire-Alarm Systems.

1.3 UNIT PRICES

- 1.3.1 To Section 28 46 13.

1.4 REFERENCES

- 1.4.1 CAN/ULC-S548-15 (R2020), Standard for devices and accessories for water type extinguishing systems.
- 1.4.2 NFPA 13, Standard for the Installation of Sprinkler Systems.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- 1.5.1 Extra Stock Materials
 - 1.5.1.1 Provide (supply and install) an additional three of each of the following fire alarm devices as directed during construction. Turn over unused surplus in addition to those devices listed below:
 - (1) Zone Addressable Modules (ZAMs).
- 1.5.2 Spare Parts
 - 1.5.2.1 Supply the following additional equipment as spare parts in a proper metal enclosure sized to accept the equipment as listed herein. Label the enclosure fire alarm spare parts. Enclosure shall be placed in the same room as the FACP.
 - (1) Supply three of each type of other installed initiating, notification, or controlling devices.
- 1.5.3 Tools
 - 1.5.3.1 Supply three of each type of any special tools required for system use and maintenance.

2 PRODUCTS

2.1 MICROPROCESSOR BASED INTELLIGENT MODULES

- 2.1.1 General
 - 2.1.1.1 Zone Addressable Modules (ZAM) shall be used for the monitoring of water flow, valve tamper, fire suppression control panels, non-addressable detectors, and for control of fans or dampers that require shutdown or manual control in an alarm condition.
 - 2.1.1.2 Monitor ZAM's shall monitor any N/O contact device and be capable of powering 2-wire smoke detectors. The ZAM will communicate the zone's status (normal, alarm, trouble) to the transponder. The ZAM's zone address shall be set at the time of installation via a dip switch package.
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- 2.1.1.3 Control ZAM's shall be able to provide supervised or non-supervised control of any control function. The ZAM will communicate the zone's status (normal, trouble) to the transponder. Each control ZAM shall provide a double pole double throw relay for switching loads of up to 120 VAC. Each common leg of the relay shall be equipped with a replaceable 2 A fuse. The ZAM's zone address shall be set at the time of installation via a dip switch package.
 - 2.1.1.4 Fire Alarm / Life Safety System shall incorporate microprocessor-based addressable modules for the monitoring and control of system Input and Output functions over a 2-wire electronic communications loop, using both broadcast and serial polling protocols. All modules shall display communications and alarm status via LED indicators. The function of each connected module shall be determined by the module type, and shall be defined in the system software through the application of a personality code. All addressing of the Microprocessor-based Addressable Modules shall be done electronically, and the electrical location of each module shall be automatically reported to the Fire Alarm Control Panel, where it may be downloaded into a PC, or printed out. The addressing of the modules will not be dependent on their electrical location on the circuit. All field wiring to the Microprocessor-based Addressable Modules shall be supervised for opens and ground faults and shall be location identified to the module of incidence. Diagnostic circuitry, and their associated indicators, with reviewable Trouble Codes, shall be integral to the Microprocessor-based Addressable Modules to assist in troubleshooting system faults. Each module shall be suitable for operation in the following environment:
 - (1) Temperature: 0°C to 49°C (32°F to 120°F)
 - (2) Humidity: 0-93% RH, non-condensing
 - 2.1.2 Single Input Module:
 - 2.1.2.1 Microprocessor-based Addressable Modules shall be used to provide one (1) supervised Class A input circuit capable of latching operation for use with contact devices, non-damped Waterflow Switches, non-latching supervisory sprinkler switches.
 - 2.1.3 Dual Input Module:
 - 2.1.3.1 Microprocessor-based Addressable Modules shall be used to provide two (2) independent supervised Class A input circuits capable of operation with contact devices. Both of the input circuits shall be terminated to, and operated from, the same microprocessor-based addressable module.
 - 2.1.3.2 Modules configured for water flow operation shall have an automatic delay of 15 seconds before reporting the water flow alarm condition to the Fire Alarm Control Panel. The module shall monitor sprinkler supervisory switches and shall automatically report the supervisory function to the Fire Alarm Control Panel each time the associated dry contact closes.
 - 2.1.4 Monitor Module:
 - 2.1.4.1 The Microprocessor-based Addressable Monitor Module shall be factory set to support one (1) supervised Class A Normally-Open active non-latching monitor circuit. The module shall automatically report the monitor function to the Fire Alarm Control Panel each time the associated dry contact closes.
 - 2.1.5 Control Relay Module:
 - 2.1.5.1 Microprocessor-based Addressable Control Relay Modules shall provide one form "C" dry relay contact rated at 2 A @ 24 VDC or 0.5 A at 120 VAC to, control external appliances or equipment processes. The control relay module shall be rated for pilot duty applications. The position of the relay contact shall be confirmed by the system firmware.
-

2.2 *TEMPERATURE SWITCHES*

- 2.2.1 To sense a temperature approaching the freezing point in any dry pipe valve enclosure or water storage container used for firefighting purposes.
- 2.2.2 Basis of design: Potter RTS series.

3 EXECUTION

3.1 *INSTALLATION*

- 3.1.1 Installation to Section 28 46 13.
- 3.1.2 Provide temperature sensor in any room containing a dry pipe valve and connect to fire alarm system to indicate a supervisory signal on the building fire alarm system annunciator for a temperature approaching the freezing point in any dry pipe valve enclosure or water storage container used for firefighting purposes.

3.2 *SITE TESTS AND INSPECTIONS*

- 3.2.1 Testing, and inspection to Section 28 46 13.
- 3.2.2 Verification to Section 28 46 13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Fire Alarm Horns.
- 1.1.2 Fire Alarm Strobes.
- 1.1.3 Combination Horn/Strobes.
- 1.1.4 Boosters.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 26 05 00 – Common Work Results for Electrical.
- 1.2.2 Section 28 46 13 – Fire-Alarm Systems.

1.3 UNIT PRICES

- 1.3.1 Submit with Tender unit prices to provide the following. Include installation and verification in the unit price:
 - 1.3.1.1 Fire alarm horn complete with wiring and conduit, based on 10 metre distance.
 - 1.3.1.2 Fire alarm strobe complete with wiring and conduit, based on 10 metre distance.
 - 1.3.1.3 Combination fire alarm horn/strobe complete with wiring and conduit, based on 10 metre distance.
 - 1.3.1.4 Unit cost of additional conduit and wire for the above items.

1.4 REFERENCES

- 1.4.1 CAN/ULC-S525:2016, Audible signaling devices for fire alarm and signaling systems, including accessories.
- 1.4.2 CAN/ULC-S526:2016, Visible signaling devices for fire alarm and signaling systems, including accessories.

1.5 SUBMITTALS

- 1.1.1 Booster battery calculations, booster power supply voltage drop calculations.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- 1.6.1 Extra Stock Materials
 - 1.6.1.1 Supply the following additional equipment as spare parts in a proper metal enclosure sized to accept the equipment as listed herein. Label the enclosure fire alarm spare parts. Enclosure shall be placed in the same room as the FACP.
 - (1) Supply three of each type of signalling device used on the project.
- 1.6.2 Spare Parts
 - 1.6.2.1 Provide (supply and install) an additional five of each of the following devices as directed during construction. Turn over unused surplus in addition to those devices listed above:
 - (1) Fire alarm horn.
 - (2) Fire alarm strobes.
 - (3) Combination horn/strobes.
- 1.6.3 Tools
 - 1.6.3.1 Supply three of each type of any special tools required for system use and maintenance.

1.7 CERTIFICATIONS

- 1.7.1 All appliances which are supplied for the requirements of this specification shall be ULC listed.
- 1.7.2 All appliances of the same manufacturer as the Fire Alarm Control Panel specified to ensure absolute compatibility between the appliances and the control panels, and to ensure that the application of the appliances are performed in accordance with the single manufacturer's instructions.
- 1.7.3 Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100% compatible with each other for the purpose intended.

2 PRODUCTS

2.1 HORNS

- 2.1.1 Vibrating horn: semi-flush mounted, 24 VDC, selectable 94 dBA or 98 dBA, suitable for installation in a standard electrical box.
- 2.1.2 Red enamel typical, or white enamel as indicated on the drawings, and as confirmed by the Owner.

2.2 MINI HORNS

- 2.2.1 Vibrating horn: semi-flush mounted, 24 VDC, 91 dBA, suitable for installation in a standard electrical box.
- 2.2.2 Red enamel typical, or white enamel as indicated on the drawings, and as confirmed by the Owner.

2.3 HORN-STROBES

- 2.3.1 Vibrating horn: semi-flush mounted, 24 VDC, selectable 94 dBA or 98 dBA, suitable for installation in a standard electrical box.
- 2.3.2 Red enamel typical, or white enamel as indicated on the drawings, and as confirmed by the Owner.
- 2.3.3 Provide horn-strobes where shown on plans and drawings. Strobe output shall be determined as required by its specific location and application from a family of 15/75 cd, 30 cd, and 110 cd devices. Strobes shall provide a synchronized flash.
- 2.3.4 Strobes shall be 24 VDC and ULC listed.
- 2.3.5 Strobe circuits shall be coordinated with audible circuits such that activation of an audible circuit results in activation of the companion strobe circuit. The strobe circuits shall be capable of being arranged such that they continue to operate in the event that the audible circuits have been silenced and remain operating until the FACP has been reset. Strobe circuits should also be coordinated with the audible circuits such that they are zoned in the same manner as the audible circuits
- 2.3.6 All strobes and combination horn strobes shall be mounted such that the bottom of the device is mounted 2000 mm (79 in) above the finished floor or 150 mm (6 in) below the ceiling, whichever is lower.

2.4 STROBES

- 2.4.1 Strobes shall be supplied where shown on plans and drawings. Strobe output shall be determined as required by its specific location and application from a family of 15/75 cd, 30 cd, and 110 cd devices. Strobes shall provide a synchronized flash.
-

- 2.4.2 Size strobe power supplies based on all strobes set at 75 cd with exact setting determined in the field to provide adequate visual signals in accordance with CAN/ULC-S524.

1.2 REMOTE BOOSTER POWER SUPPLIES

- 1.2.1 Power supply booster designed to extend power available to notification appliance circuits.
- 1.2.2 Enclosure: Steel, with lockable front panel allowing access to all interior components, surface mounted.
- 1.2.3 Functions: Contains circuits to monitor and charge batteries, control, and supervise four Class B appliance circuits, and monitor two controlling inputs from external sources.
 - 1.2.3.1 Configurable to operate at any one of three signaling rates, or to follow the main panel's notification appliance circuit.
 - 1.2.3.2 Trouble contact with 16-second delay.
- 1.2.4 Batteries: Two, sized for 24 hours of standby followed by 15 minutes of alarm.
- 1.2.5 Indicators: LEDs, one for each circuit, one for battery supervision, one for ground fault, and one for power.
- 1.2.6 Input: 120 volt circuit.

3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Installation to Section 28 46 13.

3.2 SITE TESTS AND INSPECTIONS

- 3.2.1 Testing, and inspection to Section 28 46.21 11.
- 3.2.2 Verification to Section 28 46 13.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Fire alarm interfaces to other systems.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 27 05 28.51 – Pathways for Public Address System.

1.3 REFERENCES

- 1.3.1 Ontario Building Code.
- 1.3.2 CSA C282:19, Emergency Power Supply for Buildings.

1.4 SUBMITTALS

- 1.4.1 Submit under provisions of Section 01 33 00.
- 1.4.2 Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1.4.2.1 Preparation instructions and recommendations.
 - 1.4.2.2 Storage and handling requirements and recommendations.
 - 1.4.2.3 Installation methods.
- 1.4.3 Operating and Maintenance Data: Include operating, troubleshooting, maintenance, and repair instructions for each item, with lists of spare parts, if any, and name, address, and phone number of local stocking distributors.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- 1.5.1 Extra Stock Materials:
 - 1.5.1.1 Turn over unused surplus in addition as spare parts.
- 1.5.2 Tools:
 - 1.5.2.1 Supply three of each type of any special tools required for system use and maintenance.

1.6 QUALITY ASSURANCE

- 1.6.1 Installer Qualifications: experienced door hardware installer.

1.7 DELIVERY, STORAGE, AND HANDLING

- 1.7.1 Store products in manufacturer's unopened packaging until ready for installation.

1.8 WARRANTY

- 1.8.1 Provide manufacturer's standard warranties:
 - 1.8.1.1 Magnets: Lifetime warranty.

2 PRODUCTS

2.1 SYSTEM INTERFACES

- 2.1.1 Emergency Power Systems:
 - 2.1.1.1 Provide a Supervisory input for Emergency Power Supply supervisory contacts as follows:
 - (1) Generator Common Alarm.
 - 2.1.1.2 Provide a monitoring input for Emergency Power supply contacts as follows that provides status indication but does not cause an audible alert, and automatically resets:
-

(1) Generator running.

- 2.1.2 Provide relays to interface with the following systems upon fire alarm signal:
 - 2.1.2.1 Public Address: deactivate sound systems upon fire alarm.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Do not begin installation until substrates have been properly prepared.
- 3.1.2 If substrate preparation is the responsibility of another installer, notify Consultant of unsatisfactory preparation before proceeding.

3.2 PREPARATION

- 3.2.1 Clean surfaces thoroughly prior to installation.
- 3.2.2 Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

- 3.3.1 Install in accordance with manufacturer's instructions.
- 3.3.2 Test for proper operation with building power energized; coordinate with start-up procedures of other installers.

3.4 SITE TESTS AND INSPECTIONS

- 3.4.1 Perform functional test in accordance with CAN/ULC-S1001 and Section 28 08 46 to confirm that systems operate as described. Perform test in the presence of the Contractor, sub-trades, Consultant, and applicable vendors.

3.5 PROTECTION

- 3.5.1 Protect installed products until completion of project.
- 3.5.2 Repair or replace damaged products before Substantial Performance.
- 3.5.3 Three bound copies which summarize the training instruction shall be submitted to the Owner for future reference.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Fire alarm shutdown relay for power door operators on fire separations.

1.2 RELATED REQUIREMENTS

- 1.2.1 Door Hardware Schedule.
- 1.2.2 Section 08 71 00 – Door Hardware: Locksets, exit devices, and other door hardware.
- 1.2.3 Section 28 46 13 – Fire-Alarm Systems.

1.3 REFERENCES

- 1.3.1 Ontario Building Code.
- 1.3.2 NFPA 80-13, Standard for Fire Doors and Other Opening Protectives.

1.4 SUBMITTALS

- 1.4.1 Submit under provisions of Section 01 33 00.
- 1.4.2 Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1.4.2.1 Preparation instructions and recommendations.
 - 1.4.2.2 Storage and handling requirements and recommendations.
 - 1.4.2.3 Installation methods.
- 1.4.3 Shop Drawings: Door Schedule showing each item of hardware to be installed on each door.
 - 1.4.3.1 Use door numbers on door schedule.
 - 1.4.3.2 Schedule may be combined with submittals required in other door hardware sections.
- 1.4.4 Operating and Maintenance Data: Include operating, troubleshooting, maintenance, and repair instructions for each item, with lists of spare parts, if any, and name, address, and phone number of local stocking distributors.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- 1.5.1 Tools:
 - 1.5.1.1 Supply three of each type of any special tools required for system use and maintenance.

1.6 QUALITY ASSURANCE

- 1.6.1 Installer Qualifications: experienced door hardware installer.

1.7 DELIVERY, STORAGE, AND HANDLING

- 1.7.1 Store products in manufacturer's unopened packaging until ready for installation.

1.8 WARRANTY

- 1.8.1 Provide manufacturer's standard warranties:

2 PRODUCTS

2.1 MATERIALS

- 2.1.1 General Requirements: Provide devices suitable for door type, lock type, frame type, dimensions, and overall operation.
 - 2.1.1.1 Coordinate with doors, frames, and hardware specified in other sections.
-

- 2.1.1.2 Provide all brackets, spacers, shims, lip extensions, strike boxes, and other accessory parts necessary to complete the installation.
- 2.1.1.3 Power Supplies or Transformers: Provide all necessary components to supply power to devices from building power distribution system.

2.2 POWERED DOOR OPERATORS IN FIRE SEPARATIONS

- 2.2.1 References: 2012 OBC 3.1.8.5.(2)(a), NFPA 80.
- 2.2.2 Sequence of operation: Power-operated fire doors shall be equipped with a releasing device that shall automatically disconnect the power operator at the time of fire, allowing a self-closing or automatic device to close the door regardless of power failure or manual operation.
- 2.2.3 Provide fire alarm relay to disable each power door operator as noted.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Do not begin installation until substrates have been properly prepared.
- 3.1.2 If substrate preparation is the responsibility of another installer, notify the Consultant of unsatisfactory preparation before proceeding.

3.2 PREPARATION

- 3.2.1 Clean surfaces thoroughly prior to installation.
- 3.2.2 Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION

- 3.3.1 Install in accordance with manufacturer's instructions.
- 3.3.2 Coordinate with installers of other door hardware.
- 3.3.3 Adjust installed items to operate properly without interfering with operation of door and other hardware.
- 3.3.4 Test for proper operation with building power energized; coordinate with start-up procedures of other installers.

3.4 INTERFACE WITH OTHER WORK

- 3.4.1 Connect hold opens to fire alarm system described in Section 28 46 13.
- 3.4.2 Provide spot smoke detectors to Section 28 46 31.

3.5 SITE TESTS AND INSPECTIONS

- 3.5.1 Perform functional test in accordance with CAN/ULC-S1001 and Section 28 08 46 to confirm that held doors and fire shutters release and close upon smoke detection with the presence of the Contractor, sub-trades, Consultant, and the door hardware vendor.

3.6 PROTECTION

- 3.6.1 Protect installed products until completion of project.
- 3.6.2 Repair or replace damaged products before Substantial Performance.
- 3.6.3 Three bound copies which summarize the training instruction shall be submitted to the Owner for future reference.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

- 1.1.1 Shutdown relays.

1.2 RELATED REQUIREMENTS

- 1.2.1 Section 23 34 00 – HVAC Fans.
- 1.2.2 Section 28 46 13 – Fire-Alarm Systems.

1.3 REFERENCES

- 1.3.1 Ontario Building Code.

1.4 SUBMITTALS

- 1.4.1 Submit under provisions of Section 01 33 00.
- 1.4.2 Product Data: Manufacturer's data sheets on each product to be used, including:
 - 1.4.2.1 Preparation instructions and recommendations.
 - 1.4.2.2 Storage and handling requirements and recommendations.
 - 1.4.2.3 Installation methods.
- 1.4.3 Shop Drawings: Door Schedule showing each item of hardware to be installed on each door.
 - 1.4.3.1 Use door numbers on door schedule.
 - 1.4.3.2 Schedule may be combined with submittals required in other door hardware sections.
- 1.4.4 Operating and Maintenance Data: Include operating, troubleshooting, maintenance, and repair instructions for each item, with lists of spare parts, if any, and name, address, and phone number of local stocking distributors.

1.5 QUALITY ASSURANCE

- 1.5.1 Installer Qualifications: experienced door hardware installer.

1.6 DELIVERY, STORAGE, AND HANDLING

- 1.6.1 Store products in manufacturer's unopened packaging until ready for installation.

1.7 WARRANTY

- 1.7.1 Provide manufacturer's standard warranties:

2 PRODUCTS

2.1 HVLS FANS

- 2.1.1 In buildings equipped with sprinklers, all HVLS (High Volume, Low Speed) fans shall be interlocked to shut down immediately upon receiving a sprinkler waterflow signal via the fire alarm system.

3 EXECUTION

3.1 EXAMINATION

- 3.1.1 Do not begin installation until substrates have been properly prepared.
 - 3.1.2 If substrate preparation is the responsibility of another installer, notify the Consultant of unsatisfactory preparation before proceeding.
-

3.2 *PREPARATION*

- 3.2.1 Clean surfaces thoroughly prior to installation.
- 3.2.2 Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 *INSTALLATION*

- 3.3.1 Install in accordance with manufacturer's instructions.
- 3.3.2 Coordinate with installers of other door hardware.
- 3.3.3 Adjust installed items to operate properly without interfering with operation of door and other hardware.
- 3.3.4 Test for proper operation with building power energized; coordinate with start-up procedures of other installers.

3.4 *SITE TESTS AND INSPECTIONS*

- 3.4.1 Perform functional test to confirm that held doors release upon smoke detection.

3.5 *PROTECTION*

- 3.5.1 Protect installed products until completion of project.
- 3.5.2 Repair or replace damaged products before Substantial Performance.
- 3.5.3 Three bound copies which summarize the training instruction shall be submitted to the Owner for future reference.

END OF SECTION

APPENDIX E1
CITY OF MISSISSAUGA TELECOMMUNICATIONS CABLING STANDARDS V1.4 JUNE 2023

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City of Mississauga – Network Cabling Standards

SCOPE OF SERVICES AND SERVICES LEVELS

1. GENERAL

This document describes the products and execution requirements related to the installation and maintenance of the IT Network cable distribution systems for wireless, workstation, voice (VoIP) and data at City locations in accordance with the projects scheduled by the Customer.

1.1 Scope of Service Requirements

The Contractor will be responsible for cable installations at new facilities, service work, or total re-cabling of existing sites. Installations must conform to **Belden IBDN Certified System Vendor (CSV)**.

<http://www.belden.com/resourcecenter/prutnerportal/certifiedsystemvendor/Certified-System-Vendor.cfm>

All cables and related terminations and support shall be furnished, installed, wired, tested, labeled, and documented by the Contractor as detailed in this document.

The Contractor shall have access to professional staff with an R.C.D.D. designation (The Registered Communications Distribution Designer) to review drawings to ensure that they conform to the wiring standards as indicated in this Document.

2. SCOPE OF WORK

Supply, install and test a complete Horizontal and Riser telecommunications system as specified herein and shown on the drawings provided.

The data cabling system shall comprise of the following subsystems, supplied unless noted otherwise.

- Termination of new or existing horizontal cabling on a patch panel in the network closet.
- Provision of the modular jacks and faceplates at the work area outlets.
- Electrical grounding of network rack, as per code.
- Physically secure the network rack to the floor or wall.
- Labeling and testing of all cabling systems as specified.
- Provision of all specified system documentation. (i.e. As-built drawings)
- Supply and installation of horizontal cable distribution system using J-Hooks or approved equivalent* cable supporting structure (as required) beyond conduit system already installed.
- Provide Cat 6 Modular Patch Panels for termination (new install).
- Rack and Racking accessories to be installed
- Install UPS into base of rack

2.1 Quality Assurance

The equipment, material and installation shall conform to the latest version of the applicable codes, standards and regulations:

- ANSI/EIA/TIA 568A - Commercial Building Telecommunications Cabling.
- ANSI/EIA/TIA 606 - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings (CSA T528).
- ANSI/EIA/TIA 607-Commercial Building Grounding and Bonding Requirements for Telecommunications (CSA T527).
- ANSI/EIA/TIA TSB 67-Performance Specification For Field Testing Of Unshielded Twisted Pair Cabling Systems.
- CSA C22.2 No.214 -Communication Cables.
- CENELEC EN 50173 -Performance Requirements for Generic Cabling Schemes.
- NEMA WC 63 -Performance Standard For Field Testing OD Unshielded Twisted Pair Cabling System.
- All UTP. (Unshielded twisted pair) products are to be produced from a single manufacturer unless otherwise stated.

3. PRODUCT

3.1 Data Cables

For all new applications a UTP cable shall be used. This cable shall consist of #24 AWG (CAT 6) solid conductors, formed into four individually twisted pairs and enclosed in a thermoplastic jacket. The cable shall be rated CMP FT-6 Belden/CDT. Performance shall comply with the latest draft of ANSI EIA/TIA **568-A**. Cat 6 Data cable jacket to be **Yellow in colour**.

3.2 End User Outlets

- GigaFlex PS6+ modules jacks AX IOI 065 (White)
- Wall faceplates shall be provisioned accordingly for single or multi-port outlets, Belden/CDT (White)
- Furniture outlet adapters shall be MDVO Side Entry boxes A0645273 (White).
- Furniture outlet adapters to be determined for Floor Monuments. Where applicable, MDVO (Mobile Dynamic Virtual Organizations) blank inserts shall be used in empty ports in wall and furniture jacks. Blank covers to match faceplate colours.

3.3 Patch Panels

- 482 mm, 19" Rack Mountable, 48 / 24 port, 8 position RJ45 style, High Density patch panel (Belden/CDT)
- Category 6 Cables - Horizontal and Riser Terminations:
GigaFlex PS6+ Belden/CDT, 2U, 48 Port, Black AX101458
GigaFlex PS6+ Belden/CDT, 1U, 24 Port, Black AX101456
- Pinout Termination Sequence is **T-568-A**.

3.4 Patch Cords

To be provided by the Customer.

3.5 Distribution Racks and Accessories

New Communication racks to be supplied by the cabling contractor. And shall be:

Mandatory:

- Cable Talk CTR-1977C-P48-B (4-post rack w/ Vertical Cable Management) or approved equivalent by the
- CableTalk CTR-1977-DS-B (2-Post Rack w/ Vertical Cable Management) or approved equivalent.
- Cable Talk CTR-CMS-16-B vertical cable manager or approved equivalent.
- CableTalk CTPBV-1277-SD-B 15 amp. Vertical power bar "switch disabled" or approved equivalent.
- Cage nuts NUT-CAGED-10-32K (100 pack) for 4-post racks

Optional: (if requested by the City)

- Cable Talk CTRS-F-1812-B (Single sided fixed shelf) or approved equivalent.
- Cable Talk CTRS-F-1820-B (Centre Mounted shelf) or approved equivalent.

4. INSTALLATION

4.1 General

- Installation shall conform to the applicable codes and standards (as listed in 2.1.) manufacturer's recommendations, and best industry practices.
- Grounding of each distribution rack to the communications ground bus system shall be performed by the structured cabling contractor. Mounting and fastening of the distribution rack (where applicable) to the floor shall be performed by the cable contractor.
- Cables shall be installed in trays and or conduits as provided by the electrical contractor.
- No splicing of any structured cabling will be permitted.

4.2 UPS (Uninterruptible Power Supply)

- Structured Cabling contractor will install required UPS(s) and EBM(s) in the base of the IT Rack(s).

APC UPS unit - 1.5 KVA model UPS (SMX1500RM2UCNC)

APC EBM unit - Extended Battery Module (SMX48RMBP2U) compatible with 1.5 KVA UPS

APC UPS unit – 3KVA model UPS (SMX3000RMLV2UNC)

APC EBM unit - Extended Battery Module (SMX120RMBP2U) compatible with 3KVA UPS

4.3 Data Cables

- All New LAN Data cable is to be Category 6 and is to be terminated on Category 6 connecting hardware at the wall termination for each location, and rack mounted patch panels in the communication closet.
- Label and test all cabling as detailed in this specification.

4.4 Horizontal Distribution System

- Cabling contractor to supply and install a horizontal distribution system using J-hooks or approved equivalent supporting structure, beyond provided tray/conduit, as per provided drawings.

- Supporting cable structure is to be installed into steel support structure or concrete above.
- Distribution system to be designed and installed according to consultation with Customer.
- Cable distribution to be designed according to best practices and to maintain a clean ceiling space.
- J-Hooks distribution to be designed with cable spans not to exceed 4 Feet between Zone conduit and J-Hook or J-Hook to J-Hook where applicable.

4.5 Access Point Installation

- Termination of cable for Access Point on SMB (Surface mount box) with 10 feet service slack in ceiling, or secure to supporting structure (in case of no ceiling).
- Install Cisco access points by patching to installed SMB as per customers provided drawings. (Ref: Figure A)
 - Cabling for Wifi Access Points shall be CAT6A, Plenum rated (FT6), jacket color shall be **yellow**.
 - Cabling for Wifi Access Points shall be terminated at the end of the patch panel, separate from the data jack cables. (ie on a 48-port patch panel, data jacks terminated on ports #1-40, AP's terminated on ports #41-48)

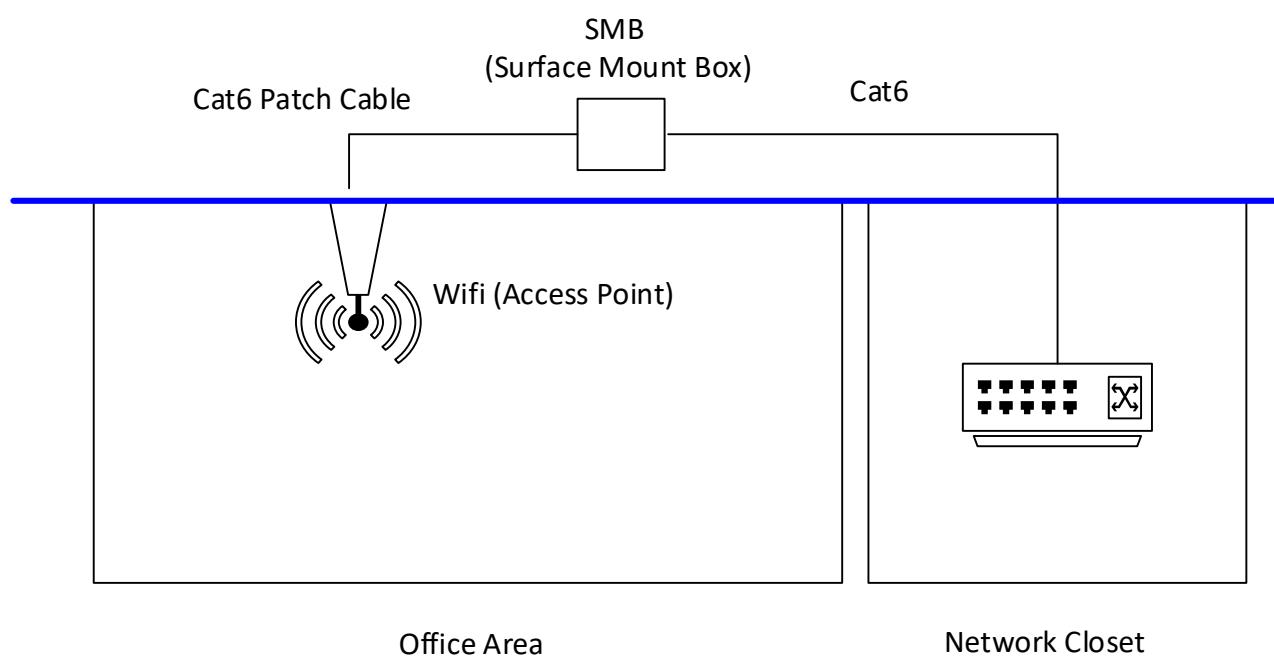


Figure A

4.6 Labeling

- Provide adhesive cable labels to meet the legibility, defacement, and adhesion requirements specified in UL 969 (Ref. D 16). In addition the labels shall meet in the general exposure requirements in UL 969 for indoor use.
- Self-laminating vinyl construction cable labels with a white printing area and a clear tail that self laminates the printed area when wrapped around the cable. The clear area should be of a sufficient length to wrap around the cable at least one and a half times.
- Mechanically print labels using a printer and follow guideline in ANSJ/TIA/EIA 606 for colour codes. Hand written labels shall not be permitted.

- All cables shall be labeled at the following locations:
- Each end of data cable lines;
- Front of Patch Panel- Data patch panels;
- Front of End User faceplates - All work area outlets;
- All Data and Analog Line horizontal UTP cables shall be labeled identically using the format as shown below

C6-XX- AAA.

C6 identifies Cat 6 cable.

XX - identifies the floor and particular Comm. Room, where applicable (ex. 4N – floor, North side, 3W – floor 3, west side)

AAA identifies the incremental cable number (i.e. 001, 002, 003 etc...)

4.7 Testing

- Horizontal distribution shall be tested and certified in accordance with ANSI/EIA/TIA and BICSI standards.
- Copper cable testing equipment testing Cat 6 cable shall be performed in accordance with ANSI/BIA/TIA 568A standard, using level 3, Category 6 cable testers. All testing software shall be the latest version, and licensed.
- Tests shall include Wire Map, Length, Insertion Loss (Attenuation), NEXT, (pair to pair), PSNEXT, ELFNEXT (pair to pair) PSELFEXT, Return Loss, ACR, PSCAR, Propagation Delay, Delay Skew. Test results shall be recorded.
- 100% of cables must be tested. Up to 5% of test may be redone in the presence of the owner.
- Any failures shall be corrected expeditiously and retested. Record of test shall be submitted in both printed and soft copy. (MS Word or Excel Format only).

4.8 Testing Results

- Cabling contractor shall submit test results in hard copy binder form which are to be left in the Communication closet. Electronic copies of the results are to be provided to the Customer in MS Excel, .pdf or Word format
- Cabling contractor to produce a cable test summary report based on the cable schedules.
- The report should indicate for each cable when it was tested successfully, the result and the length.
- The entire report must be signed by an authorized person for the cabling contractor and the end of the project.
- The test result documentation must be submitted to the owner for review no later than 10 working days following the completion of the installation.

4.9 As Built Drawings

- Cabling Contractor is required to provide an As-Built drawing of the cable installations for all drawings included in this specification to the Customer. All drawings to be provided to the Customer at the end of the project for any changes due to site conditions.
- The As-Built drawings are to include: Cable routes and outlet locations. Numbering, icons, and drawing conventions used shall be consistent throughout all documentation provided.

- Contractor shall annotate the base drawings provided by the Customer and return a hard copy (same plot size as originals) and I (one) electronic copy in Adobe Acrobat PDF format.
- All documentation shall be submitted to the Customer within 10 working days of the completion of the project.

APPENDIX E2

CITY OF MISSISSAUGA GENERAL DATA NETWORK GUIDELINES AND RESPONSIBILITIES JUNE 2023

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General Data Network Guidelines and Responsibilities

The following outlines general guidelines and responsibilities for construction projects at the City of Mississauga with regards to Data networking cabling and equipment.

Provided by GC (included in the contract):

- Procure and install Network rack (this includes cable management and PDU). Network rack needs to be secured to the floor and properly electrically grounded.
- Procure and install UPS (as per COM standard). For Cluster Sites, we will require two (2) 3kva UPS units and 4 compatible EBM's. For other sites, we will require one (1) 1.5 Kva UPS and 1 EBM.
- Install all the data cabling (as per CoM standard Cat6), this includes datajacks, covers and termination at both ends. Cabling to be terminated at data jack and patch panel sides.
- Procure and install patch panel (both fibre and ethernet) at top of network rack
- Installation of the wifi Access Points as per the design provided by Network Data Team.
- If fibre needs to be extended from Demarc to the new network closet, work with Ron Kremer to plan and install.
- Provide 2 - 30Amp Twist Lock (L5-30R) electrical outlets in the network closet directly behind the network rack.

Provided by City:

- Procure, configure and install the Cisco network switches
- Procure and preconfigure the wifi access points, and deliver to site for GC to install.
- Produce wifi heat map to display AP location and wifi coverage. This needs to be completed **prior** to the tender being released for bidding.
- Card access reader to be installed on network closet door. To be provisioned by Corporate Security's vendor Stanley Security.
- Procure and install patch cables on the network rack between patch panels and network switches. Cost of patch cables will be charged to the project.

- Project pays for any new network equipment (ie AP's, switches) over above the existing equipment in the building prior to the renovation. An inventory count will be completed prior to the renovation. Any net new equipment required over and above what was existing in SCCC prior to the renovation will be charged to the project.

APPENDIX E3
MOTOROLA MACH ALERT FIRE STATION ALERTING SYSTEM DOCUMENTATION

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Proposal

Mississauga Fire Services

Mississauga FSA Station Add-On

Fire Station 125 - Firm Proposal

June 14, 2023

The design, technical, and price information furnished with this proposal is proprietary information of Motorola Solutions, Inc. (Motorola). Such information is submitted with the restriction that it is to be used only for the evaluation of the proposal, and is not to be disclosed publicly or in any manner to anyone other than those required to evaluate the proposal, without the express written permission of Motorola Solutions, Inc.

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Section 1

INTRODUCTION

This document provides a firm proposal for the City of Mississauga Fire Services for the addition of a new station to the existing MACH Alert Fire Station Alerting (FSA) system.

The system configuration and equipment included in this system are summarized in this document. Any assumptions made in creating this system quote, and any major items/components not included in the scope of this quote, will be described.

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Section 2

STATEMENT OF WORK

2.1 System Integration Services

This Statement of Work (SOW) describes the most current understanding of the work required by DCR Engineering Services, Inc. ("DCR") and Motorola Solutions Canada, Inc. ("Motorola") to provide a successful installation and configuration of a new station to the existing MACH Alert Fire Station Alerting (FSA) System.

It is understood that this SOW may be revised during the Detailed Design Review (DDR), and through any other Change Orders that may occur during the execution of the project.

The following sections detail specific responsibilities of DCR and Motorola and Mississauga Fire in general and during various project phases. It is understood that some of "Motorola" responsibilities may be executed by the Customer or by others engaged by Motorola or Customer; however, Motorola is responsible for coordinating and ensuring proper execution.

The document delineates the general responsibilities between Motorola and Mississauga Fire Services as agreed to by contract.

2.2 Motorola Responsibilities

Motorola's responsibilities include the following:

- Schedule the implementation in agreement with Mississauga Fire Services.
- Coordinate the activities of all Motorola subcontractors under this contract.
- Administer safe work procedures for installation.
- Provide Mississauga Fire Services with the appropriate system interconnect specifications.
- Perform the Cold installation of the Motorola supplied equipment as in the equipment list.
- Provide overall Project Management services.
- Coordinate with Customer to provide on-site assistance, as necessary.
- Attend all status review meetings.
- Review of FSA overall system design.

2.2.1 Detailed Design Review

A Detailed Design Review (DDR) will be performed to review and finalize Customer requirements, Statement of Work, System Architecture Diagram, and Product List and Pricing.

- Coordinate and schedule a Kickoff Meeting with Customer, Motorola, and DCR.

- Attend any required site walks.
- Review all DCR submitted documents.
- Revise and submit to customer the following:
 - Final System Architecture Diagram.
 - Final DCR Product List and Pricing.
 - Preliminary Acceptance Test Plan
 - Final Statement of Work.

2.2.2 Design and Procurement

- Validate Equipment List by checking for valid model numbers, versions, compatible options to main equipment, and delivery data.
- Create equipment orders.
- Reconcile the equipment list(s) to the Contract.
- Procure third-party equipment if applicable.
- Configure and document panels and enclosures, including Bill of Materials (BOM).

2.2.3 Staging & System Configuration

- Storage of Customer-specific alert tones into the TONES Module(s).
- Perform Unit Functional Test for each unit (SC).
- Document unit functional factory testing results.

2.2.4 Installation

- Coordinate the real estate to mount each SC and any other station-specific equipment.
- Finalize the installation plan for each SC and any other station-specific equipment.
- Provide the following for the SC, and any other station-specific equipment per the DCR-supplied installation drawings:
 - Installation.
 - Terminations.
 - Grounding.
- Document and deliver installation drawings.
- Provide remote support to installer for guidance in installations of the Station Controller & ACE3600 RTU.

2.2.5 On-Site Functional Testing

- Configure additional station on MACH Alert GUI.
- QC proper installation and termination by electrical contractor/installer.
- Verify that equipment is operating properly and the electrical and signal levels are set accurately.

- Perform testing of each unit – Station Controller & ACE3600 RTU.
- Verify communication interfaces between devices for proper operation.
- Perform system functional testing.
- Document on-site unit and system functional testing results.
- Finalize all documentation.

2.2.6 Cutover and Final System Acceptance Testing

- Create a punch list of items based on Customer input for completion prior to the FSAT.
- Resolve punch list items that are related to the Motorola & DCR scope of work.
- Work with Customer to ensure that all stations are ready and understand the cutover plan implications for the end users and verify that information has been distributed to those users.
- During cutover, ensure that the written plan is followed and implement contingencies as required.
- Present System Acceptance Test Plan Results to the Customer.
- Obtain Customer concurrence and signoff of System Acceptance Test Plan Results.
- Conduct Final System Acceptance Test.

2.2.7 Project Close Out

- Finalize all documentation and provide an electronic as-built manual, in PDF format, on CD which will include the following:
 - System-Level Diagram
 - Site Block Diagrams
 - Equipment Inventory List
 - System Acceptance Test Plan
 - System Acceptance Test Plan Results
 - Product manuals

2.3 City of Mississauga fire Responsibilities

Mississauga Fire will assume responsibility for the installation and performance of all other equipment and work necessary for completion of this project that is not provided by Motorola. Mississauga Fire Services general responsibilities include the following, **if applicable**:

- Provide all buildings, equipment shelters, and towers required for system installation.
- Ensure communications sites meet space, grounding, power, and connectivity requirements for the installation of all equipment.
- Obtain all licensing, site access, or permitting required for project implementation.
- Obtain frequencies for project as required.
- Provide required system interconnections.

- Provide any electrical work if required.
- Will be responsible to provide backhaul.
- Provide a dedicated delivery point, such as a warehouse, for receipt, inventory and storage of equipment prior to delivery to the site(s).
- Coordinate the activities of all Mississauga Fire Services vendors or other contractors.
- Provide a reliable data radio network (if radio communications is to serve as a link to the fire stations):
- Provide a reliable Ethernet network (if Ethernet communications is to serve as a link to the fire stations):
- Approve shipping location(s).

2.4 Assumptions

Motorola has made several assumptions in preparing this proposal, which are noted below:

- City of Mississauga is responsible for provisioning the required Ethernet connection between the existing FSA dispatch location and the new fire station.
- The fire station PA system (and amplifier) is not included in this proposal.
- There is currently no requirement to integrate traffic light control with the station controller therefore this component is out of the current scope.
- All existing sites or equipment locations will have sufficient space available for the system described, as required/specified by R56.
- Power and HVAC systems will be provided by City of Mississauga.
- An existing dedicated power circuit will be available for the station controller. If none exists, the customer will provide.
- All existing sites or equipment locations will have adequate electrical power with the proper phase and voltage and site grounding to support the requirements of the system described.
- All site equipment is powered from 120 VAC.
- All existing towers will have adequate space and size to support the antenna network requirements of the system described.
- Any site/location upgrades or modifications are the responsibility of the customer.
- Any tower stress analysis or tower upgrade requirements are the responsibility of the customer.
- Approved ISED licensing provided by the customer.
- Frequencies for the system shall be provided by the existing system in place.
- The customer is responsible for radio coverage and radio traffic capacity. The current radio system channels are sufficient to carry the additional FSA data traffic.
- The fire station is within coverage of the existing RF system. If coverage issues arise, improvements will be at customer expense.
- Approved local, provincial or federal permits, as may be required for the installation and operation of the proposed equipment, are the responsibility of the customer.

- Site preparation and/or facilities improvements are not included.
- Any required system interconnections not specifically outlined here will be provided by the customer. These may include dedicated phone circuits, microwave links or other types of connectivity.

2.5 SYSTEM SUPPORT SERVICES

System Warranty and Support services have been included to match the term remaining for the existing FSA System.

2.6 SYSTEM CONFIGURATION AND EQUIPMENT SUMMARY

This Quote includes all of the equipment and services needed to add a new Fire Station to the existing MACH Alert FSA system. Refer to system documentation provided with the FSA system for details.

Below is an outline of the components that are included for the new fire station (Station 125):

- One (1) Fire Station Controller (SC) cabinet including:
 - One (1) ACE 3600 controller hardware and software
 - One (1) Motorola alerting data radio (700/800 MHz)
 - Integrated 6.5 Ah backup battery
 - A balanced line-level audio output connection to interface with the station PA (Public Address) amplifier
 - TTS / Tones module
 - Audio mixer and audio relays to control the flow of audio to the station PA (Public Address) system
 - One (1) 8-port Ethernet switch
 - Eight (8) digital output relays
 - Eight (8) digital input terminal blocks
- Software Licenses:
 - Station Controller software license
 - TTS software license
- One (1) turnout timer (TOT) display
- Two (2) mushroom push button in NEMA 4 box
- Standard spares for SC including:
 - TTS / Tones module
 - Standard mixer
 - 12/24 V Converter

- 120V Surge protector
- 8-port Ethernet switch
- ACE 3600 RTU with 700/800 MHz mobile radio
- All other required antennas and RF equipment

Section 3

PRICING

3.1 PRICING

Description	Sale Price
Station Controller Hardware & Software and ACE3600 RTU	\$28,465.00
Antenna & RF Cable	\$2,767.00
System Integration Services	\$67,350.00
Maintenance and Support (5.5 years, Starting January 2024 and expiring April 30 2029)	\$17,785.00
Total	\$116,367.00

Pricing Terms

- Prices in Canadian Dollars.
- Applicable taxes are not included.
- Pricing validity through September 15, 2023.
- System Warranty and Support services have been included to match the term remaining for the existing FSA System.

Payment Schedule

Except for any payments due on the Effective Date, The city of Mississauga will make payments to Motorola within thirty (30) days after the date of each invoice. The city of Mississauga will make payments when due in the form of a cheque, cashier's cheque, or wire transfer drawn on a Canadian financial institution and in accordance with the following milestones.

Fixed Network Equipment (FNE) payments:

- Equipment will be billed on delivery.
- System Integration Services will be billed as they are being completed.
- Motorola reserves the right to make partial shipments of equipment and to request payment upon shipment of such equipment.

Maintenance & Support:

- Services payment are due in advance for MACH Alert Support

This Proposal and any resulting contract of sale of goods and services shall be governed by the Master Agreement for VCOM Radio Communications System Upgrade dated December 31, 2011.

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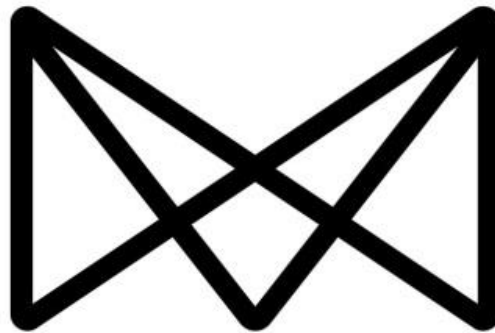
APPENDIX M1
CITY OF MISSISSAUGA MASTER SPECIFICATION FOR ENERGY MANAGEMENT CONTROL
SYSTEMS (EMCS) REV.1-2021-04-05

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City of Mississauga

*Master Specifications for
Energy Management Control Systems
(EMCS)*



MISSISSAUGA

Revised: 2021-04-05
Rev. 1

This document is confidential and the information is not to be used
or disclosed in whole or in part for any purpose other than
to evaluate this document.

Abstract of Revisions

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EMCS DESIGN GUIDELINES

Part 1 General Overview

1.1 General Overview of the CoM BAS Initiative (2020)

- 1.1.1 The City of Mississauga (CoM) is a progressive and leading-edge community in the GTA. Directed by the City's Climate Change Plan and Corporate Green Building Standard, energy management and sustainability are of high importance for the future city development. Recognizing this direction, the strategy of development and architecture of Building Automation Systems (BAS), as a crucial tool in controlling building HVAC, lighting, ice-making and other systems, is of the utmost importance. This document serves to provide a clear and concise strategy on the design of new BAS systems and their related inter-operability with other city-wide systems.
- 1.1.2 The CoM operates more than 350 buildings of various types including offices, ice rinks, pools, community centres, fire stations, libraries, parks, etc. In 2020 the CoM set out to create a new BAS/EMCS standards for the purposes of insuring consistency in the design, installation and operation of BAS controls within those facilities with the intent of modernization and upgrading to meet the standards of the next generation of Smart Buildings and Internet of Things (IOT).
- 1.1.3 A pre-qualification of BAS/EMCS products and vendors to install and service them has been carried out and a CoM Master EMCS Upgrade Specifications has been created to outline the standards for both product and installation. All CoM Pre-Qualified BAS Vendors should be familiar with these CoM Master EMCS Upgrade Specifications and the Standards outlined within.

1.2 Basis of Design

- 1.2.1 The basis of design for CoM EMCS Upgrades incorporates a dedicated CoM Enterprise server (or virtual server) complete with operating system, all necessary software tools, and an EMCS Enterprise Server Software (ESS) package that has a fully open and accessible licensing structure. The design also includes a second back-up server for storage of all system database parameters including back-up of all BAS Vendor specific field controller programming, trend data, and color graphics. Both servers are located in a CoM designated server room and be connected to the CoM wide area network ("WAN") for communication to multiple sites and multiple EMCS products.
- 1.2.2 The new system architecture utilizes Tridium Niagara Framework N4 as the pre-selected EMCS ESS package. Vendors shall coordinate with the CoM prior to the start of any project to determine the current Revision of Software in use and to be applied to SRPDC.
- 1.2.3 The anticipated EMCS upgrade work involved at each facility including new construction projects shall comprise the supply and installation of a new supervisory remote digital controller ("SRPDC"), BAS Sub-Network Controllers (SNC), remote programable digital controllers ("RPDC"), terminal equipment controllers ("TEC") and connection to other original equipment manufacturer application specific controllers ("OEMASC") over EMCS vendor supplied communication network(s).
- 1.2.4 The EMCS vendor supplied SRPDC shall be a Tridium Niagara JACE 8000 Series controllers. EMCS vendor supplied SNC shall be Tridium Niagara Edge controller(s) connected to EMCS/BAS vendor specific RPDC, TEC, and OEMASC over a field network

EMCS DESIGN GUIDELINES

utilizing BAC-net communication protocol in an open, able to exchange information system. (Where direction has been provided from CoM to connect to existing LON based controllers, LON Communication may be used).

- 1.2.5 Refer to Part 1.8 of this section for System Architecture and Communication Protocols.
- 1.2.6 All SRPDC, RPDC, TEC, EMCS Routers/Switches, etc. to be in lockable NEMA rated enclosures (except where otherwise indicated – i.e. VAV Box TEC may be mounted directly on the VAV Box). If in doubt, seek clarification from CoM before submitting a quotation on any project.
- 1.2.7 All graphics, EMCS programming, trend data, security settings, access level priorities, etc. shall be uploaded by the EMCS vendor(s) and stored on the Server for each project (without need for the involvement of others). This shall be repeated at the start of commissioning and again upon completion of deficiency clean-up and as-builts. Remote access will be provided in accordance with current City of Mississauga IT policies, procedures, and processes.

1.3 Original Equipment Manufacturer Application Specific Controllers (OEMASC).

- 1.3.1 The use of dedicated equipment controls supplied by others shall be pre-approved by the City of Mississauga Facilities Management prior to design and specification.
- 1.3.2 All equipment of this nature shall come with a BAC-net compliant communications interface communicating via BAC-net IP (or approved equivalent that is supported by the Pre-Qualified DDC Vendor Hardware interface modules – i.e. LON/Modbus/etc.). The use of Non-BAC-net communication protocols shall only be considered if Bac-Net IP is not available.
- 1.3.3 Design consultant shall fully identify and indicate the relationship between the EMCS and the dedicated controls for specific HVAC equipment as supplied by others, spelling out the points to be monitored, points to be modified, how and where to display on the graphics, responsibility of HVAC equipment representative and EMCS vendor for programming, graphics and interface, etc.
- 1.3.4 Connection to the OEM supplied controls shall be via a dedicated Sub-Net communication BUS running from the SNC to the OEMASC's. Please refer to the City of Mississauga System Architecture Diagrams (Appendix A4)
- 1.3.5 The OEMASC are mentioned in the CoM Master EMCS Upgrade Specifications, Section 253001-EMCS: Building Controllers, are to be stand-alone microprocessor-based controllers that handle the staging, sequencing, control and coordination of specific HVAC equipment and related systems components (Example Chillers/Boilers AHU's/ Other) or a dedicated application specific control system (example, Lighting Control, Power Monitoring, etc). This provides a sole source of responsibility for the equipment's performance to avoid damage to the equipment, to increase safety, and to increase vendor and manufacturer responsiveness during problem solving.
- 1.3.6 All OEMASC shall be a fully BAC-net compliant devices in order to facilitate interoperability between OEM electrical/mechanical sub-systems and BAC-net EMCS. The use of a gateway/protocol translator shall not be allowed.

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- 1.3.7 The OEM shall provide any software or hardware required to access or modify any electrical/mechanical subsystems *i.e. RTUs, VSD's, Chillers, Lighting controls and /or Electrical Monitoring & metering.
- 1.3.8 All submittals for both EMCS and OEM supplied equipment shall identify the interface between EMCS and OEM supplied controller including available points to read/write between systems.
- 1.3.9 Set up, testing and commissioning of the interface between OEMASC and the EMCS control system shall be carried out with both parties (OEM Programmer and EMCS Programmer) present on site to ensure the proper communication set up and establishing control priority levels and parameters. The cost of these services shall be included in the price from both vendors.
- 1.3.10 Specifying Consultant shall ensure to include for provision of any necessary OEM Configuration Tools and Licenses as required to connect and setup the OEM controllers and the interface to base EMCS system.

1.4 Purpose of the Guideline

- 1.4.1 The purpose of this Guideline is to provide the Project Manager, Specifying Design Engineer/Consultant, and other CoM staff involved with evaluation of BAS related projects, with an overview of the CoM EMCS design philosophy.
- 1.4.2 The Guideline outlines the design requirements for; point naming conventions, typical points and standard sequences of operation, alarming, alarm routing, training needs, commissioning, and the project turn-over process. It also details the CoM approval process (to be followed by Consultant and Contractor) from concept design through to final commissioning and turn-over.

1.5 Role of Consultant and the Use of the CoM Master EMCS Upgrade Specifications

- 1.5.1 The Master EMCS Upgrade Specifications shall be used as the basis of all EMCS design work for the City of Mississauga facilities.
- 1.5.2 Design Engineers/Consultants working for the CoM shall create their own project specific EMCS specifications to the extent necessary to meet the needs of the specific project and incorporating the elements and design principals of these Master Specifications. The project specifications shall make clear reference to the sections of these **City of Mississauga Master EMCS Upgrade Specifications** (Current Revision) within their own design document (in Division 25) .
- 1.5.3 Project based EMCS specifications issued by Design Engineers/Consultants for the design and specification of HVAC controls shall not deviate from the basic concepts and requirements set forth in the **CoM Master EMCS Upgrade Specifications**. The Master specifications provide details of the CoM expectations and requirements for:
 - Removal of Existing
 - Hardware/Devices Standards
 - Wiring/Network Standards

EMCS DESIGN GUIDELINES

- Installation Standards
 - Alarms and Alarm Routing
 - Trend setup
 - Active Directory and User Access Levels
- 1.5.4 The Design Engineer/Consultant should also clearly identify that it is the **City of Mississauga Pre-Qualified EMCS Vendor's** responsibility to make note of any deviations between the Project Specific Specifications and **City of Mississauga Master Specifications for EMCS Upgrades (Current Revision)**. Such deviations shall be brought to the attention of the City of Mississauga project manager prior to tender closing.
- 1.5.5 The Design Engineer/Consultant's primary input for new EMCS installations and modifications will be as follows;
- Summary Point Matrix including an indication of points/equipment to be controlled, and locations on the drawings.
 - The Sequence of Operation for Equipment to be controlled
 - Control System Schematic Drawings
 - EMCS Design Consultant shall make use of the material provided in the **Appendices** of the Master Specifications and attached to this Guideline including:
 - A1- CoM Point Naming Convention
 - A2- CoM Building ID and Type List
 - A3- CoM EMCS Cabinet Installation Standard
 - A4- CoM System Architectures
 - A5- CoM Graphical Standard
 - A6- CoM Points List and Typical Sequences of Operation
 - B1 – CoM Points List Template
 - B2 – CoM Sample Points List
 - B3 – CoM Pre-Commissioning Checklist Form
 - B4 – CoM Project Acceptance Form
 - B5 – CoM Training Sign-Off Form
 - B6 – CoM Sample Project Specification EMCS Section
 - Electronic versions will be made available to the Consultant and shall be modified/completed to meet the particular project needs of individual projects.
- 1.5.6 **Note to Contractors:** The **CoM Master EMCS Upgrade Specifications** document should be read in conjunction with the Project Specific Design and Specifications for any New and/or Replacement Energy Management Control System (EMCS), and EMCS upgrade projects designed for the City of Mississauga, Ontario.
- 1.5.7 Because the **CoM Master EMCS Upgrade Specifications** are periodically updated, the current and most recent version of this document should be obtained directly from the City of Mississauga, Ontario Project Manager at the start of each project.

EMCS DESIGN GUIDELINES

1.6 Creation of Points List and Point Naming Convention

- 1.6.1 Consultants must adhere to CoM Standards for points list and point naming convention, please refer to attached **Appendices A1 and A6**.

1.7 Application of Building ID and Type

- 1.7.1 Each CoM has a unique **Building ID** tag which shall form a part of the point name and is to be used in the integration of other software applications (Room Booking, Asset Planning, etc) with the EMCS. The application of sequences applies different operational modes and control settings based on **Building Type**. Refer to Appendix A2 for a list of Building ID tags and Type of facility. Refer to Appendix A6 for the application of different control modes.

1.8 System Architecture and Communication Protocols

- 1.8.1 The System Architecture is dependent on the size of facility, type of project, and the availability of CoM IT infrastructure **refer to Appendix A4**. Design Engineer/Consultant should discuss the different system topologies and obtain approvals for the final selection of appropriate System Architecture design.
- 1.8.2 The intended design of all specified system Architectures requires an SRPDC, set-up and programmed to manage and monitor communication between SNC and/or all field level controllers (RPDC, TEC, OEMASC). All EMCS field level controllers shall be capable of standalone operation on loss of communication with the SRPDC and/or SNC. No physical control points shall reside on the either the SRPDC or SNC.
- 1.8.3 All system graphics, EMCS programming, trend data, security settings, access level priorities, etc shall be uploaded by the EMCS/BAS vendor(s) and stored on the Server (without need for the involvement of the other contractors).

1.9 Application of Typical System Points List and Standard Sequences

- 1.9.1 In order to maintain consistency in both the design and operation of BAS control systems, the CoM has developed a list of Typical Points and Standard Sequence of Operation to be applied to each typical system.
- 1.9.2 The standard sequences are generic in nature and are meant to form the basis of design for all CoM BAS control projects. The sequences shall be used as the initial starting point for each project, customized by the specifying Design Engineer/Consultant and tailored for the specifics of individual project and system requirements. Refer to **Appendix A6** for typical points and standard sequences.
- 1.9.3 All project specific sequences are to be submitted to the CoM for review and approval prior to Tenders (refer to Guideline Part 1.13 **BAS Design and Construction Approval Process**).
- 1.9.4 Final schedules, set-points, limits, dead bands, etc shall be determined during commissioning and then documented in the as-built drawings and final project close out documentation.

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- 1.9.5 Where new HVAC systems/design concepts are not listed in the Appendices, the Design Engineer/Consultant shall follow the same naming convention format and broader BAS design principles as outlined in the **CoM Master EMCS Upgrade Specifications** to create a new Points List and Typical Sequence of Operation for integration and use in the subsequent revisions of **CoM Master EMCS Upgrade Specifications**. Once created by Design Engineer/Consultant, the points list and sequences will be presented to the CoM Project Manager for distribution to Stakeholders, review and approval.

1.10 CoM Graphical Standards

- 1.10.1 The CoM uses a common graphical interface for all sites, set-up and designed specifically to the CoM organizational structure and user access requirements. Each project shall conform to the Graphical Standard and shall seek approval of system graphics before deploying them on site.
- 1.10.2 Each project will require the full development of **NEW** site-specific customized graphics in accordance with the CoM Graphical Standard as outlined **Appendix A5**. The contractor shall utilize the CoM Graphical Standard in conjunction with existing completed graphical workstation(s) as the starting point of development of new graphics. BAS Vendor shall work closely with the CoM assigned approver and Design Engineer/Consultant to create project/site specific custom graphics.
- 1.10.3 To accomplish the above, the BAS Vendor shall meet with the Owner and Design Engineer/Consultant within 2 weeks of the Project Start-Up meeting to specifically discuss the requirements for new system graphics and associated plan of execution.
- 1.10.4 The BAS Vendor and Design Engineer/Consultant shall anticipate a reiterative process whereby the graphics will be submitted multiple times for review and comment, followed by revision(s) until both the Owner is satisfied with the end result (and graphics approval is granted).

1.11 CoM Alarming & Guideline

- 1.11.1 Refer to **Appendix A6, Part 1.4 Alarm Management** and subsequent Typical Sequence of operation.

1.12 CoM Commissioning Standards

- 1.12.1 The commissioning agent (Cx) may be a third party service, design consultant, or CoM employee as designated and outline in the Consultant's project specifications.
- 1.12.2 Anticipated commissioning process and the role of the EMCS vendor are referenced in these Master Specifications Section 01 91 13 and Section 25 01 11

1.13 BAS Design and Construction Approval Process

- 1.13.1 All new EMCS designs shall be submitted to the City of Mississauga Facilities Management for review prior to tendering of any projects
- 1.13.2 Preliminary Design Review:
- Assigned CoM Approver to review:
 - The use of Correct Point Naming convention

EMCS DESIGN GUIDELINES

- The specification of required points and application of correct sequences (Refer to **Appendix A1 and A6** for Point Naming Convention, Points Lists and Standard Sequence of Operation)

1.13.3 Final Design Review (prior to tender):

- Assigned CoM Approver to review:
- Specification uses correct references to **CoM Master EMCS Upgrade Specifications for EMCS Upgrade** (of latest revision)
- Correct use of (or reference to) CoM BAS Forms and Standards (Refer to **Appendix A and B**)
- Proper description of system Architecture and the Pre-Approved Products/ Pre-Qualified Vendors (Refer to **Appendix A4 and CoM List of Pre-Approved Vendors/Products**)
- Proper reference to additional CoM Submittal and Close-Out Documentation approval process
- Inclusion of CoM Forms for Commissioning/Closeout/Training Approval (Refer to **Appendix B3, B4 and B5**)

1.13.4 Pre-Construction /Submittal Review

- Following the Design/Tender phase the next review by CoM Assigned Approver shall occur during the Pre-Construction Phase. Specifying project Design Engineer/Consultant shall also be responsible to conduct their OWN engineering review concurrently with the CoM review, and shall incorporate the CoM Assigned Approver's comments on the returned shop drawings.
- Assigned CoM Approver to review submittals to confirm:
- Conformance to the specified products and installation standards detailed in the CoM Master EMCS Upgrade Specifications (Refer to **CoM Master EMCS Upgrade Specifications Section 25 30 01 EMCS Building Controllers Family of Controllers, and Section 25 30 02 EMCS Field Control Devices**)
- Shop drawing submittal package has all necessary information (Refer to CoM Master EMCS Upgrade Specifications Section 25 05 02 EMCS Submittals and Review Process)
- Design has correct System Architecture and the Use of Pre-Qualified Products
- Application of Correct Sequences and Points/System
- Use of proper point naming convention

1.13.5 Construction Phase Review:

- Assigned CoM Approver to review close-out submittals to confirm:
- System graphics have been reviewed by CoM Facility Operations to ensure conformance with CoM Graphical Standard (Refer to **Appendix A5**)
- Graphics have been tested by CoM Facility Operations and/or Commissioning Agent to confirm that:
- Links are operational and correct,

EMCS DESIGN GUIDELINES

- PDF of As-Builts and written sequences are properly linked to the graphics and are up to date with final settings,
- active directory and user access levels are correct and functional
- specified database integration (ie room booking software) is functional and correctly linked to proper systems
- Activity Modes have been set-up and programmed including display of active operational mode on system graphics,
- All alarms (Environmental, Maintenance, Critical, Energy) are set up and alarm routing is correct.
- All systems graphics have an associated settings page with all adjustable control variables, alarm settings and time delays.
- Verification of Trend Data Set-Up, Auto Back-up of Files & software
- Site Verification that CoM Demolition & Installation standards have been met.
- Review of Closeout Data (CoM Forms – Provisional Acceptance, Commissioning Reports, Final Acceptance, Training Acknowledgement, etc). Refer to **Appendix B**

END OF SECTION

SUBMITTAL PROCEDURES

Part 1 General 2

 1.1 RELATED REQUIREMENTS..... 2

 1.2 REFERENCES 2

 1.3 ADMINISTRATIVE 2

 1.4 SHOP DRAWINGS AND PRODUCT DATA..... 2

 1.5 SAMPLES..... 5

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 1.7 CERTIFICATES AND TRANSCRIPTS..... 5

Part 2 Products..... 5

 2.1 NOT USED..... 5

Part 3 Execution 5

 3.1 NOT USED..... 5

SUBMITTAL PROCEDURES

Part 1 General

1.1 RELATED REQUIREMENTS

- 1.1.1 Section 25 05 01 EMCS General Requirements.
- 1.1.2 Section 25 05 02 EMCS Submittals and Review Process

1.2 REFERENCES

- 1.2.1 None

1.3 ADMINISTRATIVE

- 1.3.1 Submit to Consultant submittals listed for review. Submit promptly and in orderly sequence to not cause delay in Work. Failure to submit in ample time is not considered a sufficient reason for extension of Contract Time and no claim for extension by reason of such default will be allowed.
- 1.3.2 Do not proceed with Work affected by submittal until review is complete.
- 1.3.3 Present shop drawings, product data, samples and mock-ups in SI Metric units.
- 1.3.4 Where items or information is not produced in SI Metric units converted values are acceptable.
- 1.3.5 Review submittals prior to submission to Consultant. This review represents that necessary requirements have been determined and verified, or will be, and that each submittal has been checked and co-ordinated with requirements of Work and Contract Documents. Submittals not stamped, signed, dated and identified as to specific project will be returned without being examined and considered rejected.
- 1.3.6 Notify Consultant, in writing at time of submission, identifying deviations from requirements of Contract Documents stating reasons for deviations.
- 1.3.7 Verify field measurements and affected adjacent Work are co-ordinated.
- 1.3.8 Contractor's responsibility for errors and omissions in submission is not relieved by Consultant's review of submittals.
- 1.3.9 Contractor's responsibility for deviations in submission from requirements of Contract Documents is not relieved Consultant review.
- 1.3.10 Keep one reviewed copy of each submission on site.

1.4 SHOP DRAWINGS AND PRODUCT DATA

- 1.4.1 The term "shop drawings" means drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are to be provided by Contractor to illustrate details of a portion of Work.
- 1.4.2 Where applicable as indicated elsewhere, submit drawings stamped and signed by professional engineer registered or licensed in Province of Ontario, Canada.
- 1.4.3 Indicate materials, methods of construction and attachment or anchorage, erection diagrams, connections, explanatory notes and other information necessary for

SUBMITTAL PROCEDURES

completion of Work. Where articles or equipment attach or connect to other articles or equipment, indicate that such items have been co-ordinated, regardless of Section under which adjacent items will be supplied and installed. Indicate cross references to design drawings and specifications.

- 1.4.4 Allow 10 days for Consultant's review of each submission.
- 1.4.5 Adjustments made on shop drawings by Consultant are not intended to change Contract Price. If adjustments affect value of Work, state such in writing to Consultant prior to proceeding with Work.
- 1.4.6 Make changes in shop drawings as Consultant may require, consistent with Contract Documents. When resubmitting, notify Consultant in writing of revisions other than those requested.
- 1.4.7 Accompany submissions with transmittal letter containing:
 - 1.4.7.1 Date
 - 1.4.7.2 Project title and number
 - 1.4.7.3 Contractor's name and address
 - 1.4.7.4 Identification and quantity of each shop drawing, product data and sample
 - 1.4.7.5 Other pertinent data
- 1.4.8 Submissions include:
 - 1.4.8.1 Date and revision dates
 - 1.4.8.2 Project title and number
 - 1.4.8.3 Name and address of:
 - 1.4.8.3.1 Subcontractor
 - 1.4.8.3.2 Supplier
 - 1.4.8.3.3 Manufacturer
 - 1.4.8.4 Contractor's stamp, signed by Contractor's authorized representative certifying approval of submissions, verification of field measurements and compliance with Contract Documents.
 - 1.4.8.5 Details of appropriate portions of Work as applicable:
 - 1.4.8.5.1 Fabrication.
 - 1.4.8.5.2 Layout, showing dimensions, including identified field dimensions, and clearances.
 - 1.4.8.5.3 Setting or erection details.
 - 1.4.8.5.4 Capacities.
 - 1.4.8.5.5 Performance characteristics.
 - 1.4.8.5.6 Standards.
 - 1.4.8.5.7 Operating weight.
 - 1.4.8.5.8 Wiring diagrams.
 - 1.4.8.5.9 Single line and schematic diagrams.
 - 1.4.8.5.10 Relationship to adjacent work.

SUBMITTAL PROCEDURES

- 1.4.9 After Consultant's review, distribute copies.
- 1.4.10 Submit electronic copy of shop drawings for each requirement requested in specification Sections and as Consultant may reasonably request.
- 1.4.11 Submit electronic copies of product data sheets or brochures for requirements requested in specification Sections and as requested by Consultant where shop drawings will not be prepared due to standardized manufacture of product.
- 1.4.12 Submit electronic copies of test reports for requirements requested in specification Sections and as requested by Consultant.
 - 1.4.12.1 Report signed by authorized official of testing laboratory that material, product or system identical to material, product or system to be provided has been tested in accord with specified requirements.
 - 1.4.12.2 Testing must have been within 3 years of date of contract award for project.
- 1.4.13 Submit electronic copies of certificates for requirements requested in specification Sections and as requested by Consultant.
 - 1.4.13.1 Statements printed on manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that product, system or material meets specification requirements.
 - 1.4.13.2 Certificates must be dated after award of project contract complete with project name.
- 1.4.14 Submit electronic copies of manufacturer's instructions for requirements requested in specification Sections and as requested by Consultant.
 - 1.4.14.1 Pre-printed material describing installation of product, system or material, including special notices and Material Safety Data Sheets concerning impedances, hazards and safety precautions.
- 1.4.15 Submit electronic copies of Manufacturer's Field Reports for requirements requested in specification Sections and as requested by Consultant.
- 1.4.16 Documentation of the testing and verification actions taken by manufacturer's representative to confirm compliance with manufacturer's standards or instructions.
- 1.4.17 Submit electronic copies of Operation and Maintenance Data for requirements requested in specification Sections and as requested by Consultant.
- 1.4.18 Delete information not applicable to project.
- 1.4.19 Supplement standard information to provide details applicable to project.
- 1.4.20 If upon review by Consultant, no errors or omissions are discovered or if only minor corrections are made, copies will be returned, and fabrication and installation of Work may proceed. If shop drawings are rejected, noted copy will be returned and resubmission of corrected shop drawings, through same procedure indicated above, must be performed before fabrication and installation of Work may proceed.

SUBMITTAL PROCEDURES

1.5 SAMPLES

- 1.5.1 Submit for review samples in duplicate as requested in respective specification Sections. Label samples with origin and intended use.
- 1.5.2 Deliver samples prepaid to Consultant's business address.
- 1.5.3 Notify Consultant in writing, at time of submission of deviations in samples from requirements of Contract Documents.
- 1.5.4 Where colour, pattern or texture is criterion, submit full range of samples.
- 1.5.5 Adjustments made on samples by Consultant are not intended to change Contract Price. If adjustments affect value of Work, state such in writing to Consultant prior to proceeding with Work.
- 1.5.6 Make changes in samples which Consultant may require, consistent with Contract Documents.
- 1.5.7 Reviewed and accepted samples will become standard of workmanship and material against which installed Work will be verified.

1.6 MOCK-UPS

- 1.6.1 N/A

1.7 CERTIFICATES AND TRANSCRIPTS

- 1.7.1 Immediately after award of Contract, submit Workers' Compensation Board status.
- 1.7.2 Submit transcription of insurance immediately after award of Contract.

Part 2 Products

2.1 NOT USED

- 2.1.1 Not Used.

Part 3 Execution

3.1 NOT USED

- 3.1.1 Not Used.

END OF SECTION 01 33 00

REGULATORY REQUIREMENTS

Part 1 General 2

 1.1 REFERENCES..... 2

 1.2 RELATED SECTIONS..... 2

 1.3 CODES, BY-LAWS, REGULATIONS, ORDINANCES 2

 1.4 FIRE PROTECTION REQUIREMENTS..... 2

Part 2 Products..... 3

 2.1 NOT USED 3

Part 3 Execution..... 3

 3.1 NOT USED 3

REGULATORY REQUIREMENTS

Part 1 General

1.1 REFERENCES

- 1.1.1 Ontario Building Code (Latest Edition)

1.2 RELATED SECTIONS

- 1.2.1 All

1.3 CODES, BY-LAWS, REGULATIONS, ORDINANCES

- 1.3.1 Carry out work in accordance with requirements of the latest edition of the applicable provincial building code, including all amendments and revisions.
- 1.3.2 Comply with requirements, regulations and ordinances of other authorities having jurisdiction.
- 1.3.3 Where it is necessary to carry out work outside property lines, such as sidewalks, paving, concrete curbs, service connections, comply with applicable requirements of municipal authorities having jurisdiction. Any permits and fees associated with this work shall be included in the Contract price.
- 1.3.4 Codes, by-laws, regulations, ordinances referred to in these Contract Documents are the latest published edition including published revisions and amendment, at time of Tender Submission.
- 1.3.5 In case of conflict between codes, by-laws, regulations, ordinances, specifications, follow most stringent requirements.

1.4 FIRE PROTECTION REQUIREMENTS

- 1.4.1 Refer to technical section of specifications and drawings for specific fire protection requirements.
- 1.4.2 Test methods used to determine fire hazard classification and fire endurance rating shall be as required by The Building Code.
- 1.4.3 Upon request, furnish the Owner with evidence of compliance with project fire protection requirements.
- 1.4.4 Materials and components used to construct fire rated assemblies and materials requiring fire hazard classification shall be listed and labelled, or otherwise approved, by fire rating authority. Labelled materials and their packaging shall bear fire rating authorities label showing product classification.
- 1.4.5 Materials having a fire hazard classification shall be applied/installed in accordance with manufacturer's directions.
- 1.4.6 Fire rated assemblies shall be constructed in strict accordance with applicable assembly design report. Deviation will not be allowed.
- 1.4.7 Construct fire rated assemblies as continuous, uninterrupted elements except for permitted openings. Extend fire rated walls and partitions from floor to underside of structural deck above.
- 1.4.8 Fill and patch voids and gaps around opening and penetrations in and at perimeter of fire rated assemblies to maintain continuity and integrity of fire separation and smoke seal to the requirements of jurisdictional authorities.

REGULATORY REQUIREMENTS

Part 2 Products

2.1 NOT USED

2.1.1 Not Used.

Part 3 Execution

3.1 NOT USED

3.1.1 Not Used.

END OF SECTION 01 41 00

QUALITY CONTROL

Part 1	General	2
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1.2	REFERENCES.....	2
1.3	INSPECTION OF WORK	2
1.4	REJECTED WORK	2
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Part 2	Products.....	3
2.1	Not Used.....	3
Part 3	Execution.....	3
3.1	Not Used.....	3

QUALITY CONTROL

Part 1 General

1.1 RELATED SECTION

- 1.1.1 All

1.2 REFERENCES

- 1.2.1 Canadian Construction Association
 - 1.2.1.1 CCA-1 Stipulated Price Subcontract

1.3 INSPECTION OF WORK

- 1.3.1 The Owner, Consultant, and Commissioning Agent are to have access to the work for inspection purposes. Co-operate and provide such access.
- 1.3.2 Give timely notice requesting inspection if work is designated for special tests, inspections or approvals or if work is to be covered up.
- 1.3.3 Any work which is covered or permitted to be covered that is subject to inspection or before any special tests and approvals are completed is to be uncovered and have the inspections satisfactorily completed. Pay costs of such remedial work.
- 1.3.4 Arrange for and be responsible for all required inspections of the Work including mechanical and electrical inspections.
- 1.3.5 Make all payments required for inspection permits.
- 1.3.6 Inform all inspection agencies of need for inspections.
- 1.3.7 Request that Consultant conduct all inspections concerning changes in the Work and requests for payment.

1.4 REJECTED WORK

- 1.4.1 Defective work, whether the result of poor workmanship, use of defective materials or damage through carelessness or other act, and whether incorporated in the work or not, which has been rejected by the owner as failing to conform to the Contract documents, is to be removed promptly and replaced in accordance with the Contract documents at the Contractor's expense.
- 1.4.2 If in the opinion of Consultant, it is not expedient to correct defective work, or work not done in accordance with the Contract documents, Consultant may deduct from the Contract price the difference in value between the work done and that called for in the Contract documents, the amount of which is to be determined by Consultant.

1.5 STANDARDS

- 1.5.1 Within the text of these specifications, reference is made to the following standards:
 - 1.5.1.1 ASTM - American Society for Testing and Materials
 - 1.5.1.2 CAN/CGSB - Canadian General Standards Board
 - 1.5.1.3 CSA - Canadian Standards Association
 - 1.5.1.4 FM - Factory Mutual Engineering Corporation
 - 1.5.1.5 ULC - Underwriters' Laboratories of Canada
 - 1.5.1.6 CGA - Canadian Gas Association

QUALITY CONTROL

- 1.5.2 The testing of materials not elsewhere specified, or normally carried out as a matter of standard construction practice, may be requested by Consultant to prove conformance with Standards, and will be paid for by Consultant. Materials that fail are to be replaced and re-tested at the Contractor's expense and costs incurred by the Owner for the original test(s) shall be deducted from the Contract value.
- 1.5.3 The referenced standards and any amendments on the day of receipt of tenders shall be applicable to the work during the duration of the Contract, unless otherwise specified.

1.6 CONTRACTOR'S RESPONSIBILITIES *(IF TESTING IS REQUIRED)*

- 1.6.1 Contractor shall be responsible for all of the following:
 - 1.6.1.1 Notify the Owner and testing agency minimum 48 hours in advance of operations to allow for assignment of personnel and scheduling of tests without causing delay in work.
 - 1.6.1.2 Provide testing agency with access to work at all time.
 - 1.6.1.3 Supply casual labour and other incidental services required by testing agency.
- 1.6.2 When initial inspection and testing indicates non-compliance with Contract documents, any subsequent re-inspection and re-testing occasioned by non-compliance shall be performed by same testing agency at the Contractor's cost.
- 1.6.3 When initial inspection and testing indicates non-compliance with Contract documents, costs of that initial inspection and testing shall be charged to the Contractor.

1.7 TOLERANCES FOR INSTALLATION OF WORK

- 1.7.1.1 Unless acceptable tolerances are otherwise specified in a Section or are otherwise required for proper functioning of equipment, tolerances for site services, and mechanical and electrical systems are defined as follows:
 - 1.7.1.2 "Plumb and Level" shall mean plumb or level within 1 mm in 1 metre.
 - 1.7.1.3 "Square" shall mean not in excess of 10 seconds lesser or greater than 90 degrees.
 - 1.7.1.4 "Straight" shall mean within 1 mm under or over a 1 Metre long straightedge
- 1.7.2 All work must be installed in accordance with the tolerances specified in Paragraph 1.7 above.

Part 2 Products

- 2.1 Not Used

Part 3 Execution

- 3.1 Not Used

END OF SECTION 01 45 00

CLOSEOUT PROCEDURES

Part 1 General..... 2

1.1 RELATED REQUIREMENTS..... 2

1.2 REFERENCES 2

1.3 DEFINITIONS OF ACCEPTANCE TERMS 2

1.4 TAKE OVER PROCEDURE 3

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Part 2 Products..... 5

2.1 NOT USED 5

Part 3 Execution 5

3.1 NOT USED 5

CLOSEOUT PROCEDURES

Part 1 General

1.1 RELATED REQUIREMENTS

- 1.1.1 01 33 00 Submittal Procedures
- 1.1.2 01 78 00 Closeout Submittals
- 1.1.3 25 01 11 EMCS Start-Up, Verification and Commissioning.

1.2 REFERENCES

- 1.2.1 None

1.3 DEFINITIONS OF ACCEPTANCE TERMS

1.3.1 Real End of the Work

- 1.3.1.1 The work shall be considered finished when the deficiencies are completed in accordance to Consultant's evaluation.

1.3.2 Contractor's Inspection

- 1.3.2.1 The Contractor and his subcontractors shall conduct an initial inspection of the work prior to Pre-Commissioning Activities (functional testing, performance testing, etc.) and shall attempt to correct all noted deficiencies. Contractor is to provide a written list of deficiencies to the Owner and Consultant using the City of Mississauga Project Close Out Provisional Acceptance Forms.

1.3.3 Provisional Acceptance

- 1.3.3.1 The provisional acceptance shall follow the end of work on site as necessary to obtain substantial completion and shall signal the start of the warranty.
- 1.3.3.2 The Contractor shall make a request for the provisional acceptance by completing City of Mississauga **Project Close Out Provisional Acceptance Form** and related functional testing. This shall occur only when the system has been completely installed, calibrated, tested and is operational
- 1.3.3.3 Provisional Acceptance forms must be signed off by Contractor/Owner/Consultant, marking the mutual agreement of Substantial Completion of the system.
- 1.3.3.4 If Consultant judges that the tests are not adequately done by the Contractor prior to his request for provisional acceptance, the charges incurred by the Consultant and/or commissioning agent for an additional visit shall be charged to the Contractor.

1.3.4 Final Inspection:

- 1.3.4.1 Consultant, Contractor, and Owner to inspect Work and identify defects and deficiencies.
- 1.3.4.2 Contractor to correct Work as directed prior to Commissioning.

1.3.5 Commissioning

CLOSEOUT PROCEDURES

- 1.3.5.1 Commissioning shall be carried out by the contractor and Owner's designate commissioning agent only after Provisional acceptance has been granted.
- 1.3.5.2 As a part of the new control system installation, the contractor shall first fully test and commission the entire system. All pre-commissioning activities and testing shall be fully documented and submitted with the Provisional Acceptance Forms. This includes a full point-to point check-out (functional test) of the system, provide completed Pre-commissioning (Functional Test) Check List to Owner's designate Commissioning Agent.
- 1.3.5.3 Contractor shall assistance, staff and materials to support the Owner's designate Commissioning Agent activities.
- 1.3.5.4 Contractor's designate programmer/control technician to carry out the operator commands and adjustments to software parameters as directed by the Owners designated Commissioning Agent.
- 1.3.5.5 Owners designate commissioning agent to prepare commissioning report outlining results of functional and performance testing including a list of any outstanding deficiencies to be completed by the contractor to obtain Final Acceptance.
- 1.3.6 Final Acceptance
 - 1.3.6.1 Application for final acceptance shall follow within a maximum of ten (10) working days from receipt of Commissioning report. Contractor shall complete all outstanding deficiencies, submitted as built and O&M documentation and completed training to receive Final Acceptance.
 - 1.3.6.2 Final Acceptance forms must be signed off by Contractor/Owner/Consultant, marking the mutual agreement of acceptance of the system.

1.4 TAKE OVER PROCEDURE

- 1.4.1 Substantial Completion
 - 1.4.1.1 Refer to Part 1 above for definition of terms for acceptance. All Forms must be completed by the Contractor, Submitted and Signed by all parties (Contractor/Consultant/Owner) for a stage to be considered Complete
 - 1.4.1.2 Substantial Completion cannot be granted without completed and signed City of Mississauga **Project Close Out Provisional Acceptance Forms**.
 - 1.4.1.3 When the Contractor is satisfied that all deficiencies have been corrected, the Contractor shall request, in writing, a Substantial Completion Inspection along with the submission of the **Project Close Out Provisional Acceptance Form**. Once forms are submitted there will be a Final Inspection to confirm completion, the inspection team shall consist of the Owner, Consultant and Contractor.
 - 1.4.1.4 **Final Inspection:** Contractor to complete the **Project Close Out Provisional Acceptance Forms** and Submit to the Owner and Consultant indicating satisfactory completion of the "Contractor's Inspection" and signifying readiness for Final Inspection. Commissioning shall be scheduled but cannot take place until the Final Inspection is complete. Inspection Team shall conduct a final inspection of the system installation and create a list of any noted additional deficiencies.

CLOSEOUT PROCEDURES

- 1.4.1.5 **Deficiencies:** Following final inspection, a list of all noted deficiencies to date shall be drawn up and include with the deficiencies previously listed on the back pages of **Project Close Out Provisional Acceptance Form**. The Contractor shall correct all deficiencies in a satisfactory manner and within agreed upon timelines.
- 1.4.1.6 **Declaration of Completion:** (Signed Project Close Out Provisional Acceptance Form): When it is mutually agreed upon by the inspection team that the work needed for Provisional Acceptance is complete, and the value of outstanding work is less than the contractual obligations required for Substantial Completion (per contract documents) all parties shall sign the **“Project Close Out Provisional Acceptance Form”** and shall agree upon the date to be noted for Substantial Completion.
- 1.4.1.7 **Certificate of Substantial Completion:** The Owner or Payment Certifier will state in writing, upon agreement with the above declaration, their approval of the inspected work, as “Substantially Complete.” The Contractor shall publish this Certificate of Substantial Completion in a recognized industry trade journal (e.g. Daily Commercial News) to establish the date for commencement of the lien period.
- 1.4.1.8 **Commencement of Lien and Guarantee Period:** The date of publication of the Owner’s certificate of substantial completion, as above, shall mean immediate commencement of the lien period as specified by Provincial lien laws, and commencement periods. Neither the Contractor, the subcontractors nor any supplier shall carry out any work except for repairs or replacements under guarantee on the project during the lien period.

1.5 TOTAL PERFORMANCE

1.5.1 Final Acceptance

- 1.5.1.1 Prior to requesting a final acceptance do the following:
 - 1.5.1.1.1 Complete commissioning with Owner’s designate Commissioning Agent.
 - 1.5.1.1.2 Schedule and completed all outstanding deficiencies
 - 1.5.1.1.3 Submit As-Built Documentation and where EMCS has been upgraded, update System Graphics to include Links to updated PDF’s of As-Built
 - 1.5.1.1.4 Submit all Project Close-Out Documentation
 - 1.5.1.1.5 Complete all Training
 - 1.5.1.1.6 Submit a final request for payment in accordance with Contract requirements and incorporating all approved changes to the Contract price.
 - 1.5.1.1.7 Submit completed and signed City of Mississauga **Project Close Out Final Acceptance Forms** to the Owner and Consultant signifying a request for a Final Acceptance. Final Acceptance Form to include a copy of all previous deficiencies noting dates corrected and indicating that the work is totally performed, and the project is ready for Final Acceptance. A final inspection will be required to verify completion and shall be carried out by the same parties involved in the Provisional Acceptance Stage.

CLOSEOUT PROCEDURES

- 1.5.1.2 If all deficiencies have not been corrected, in the opinion of the Owner and/or Consultant a final deficiency list shall be prepared and sent to the Contractor in the same manner as specified herein for the Substantial Completion and the inspection procedure repeated until all items have been completed to the satisfaction of the Owner and/or Consultant.
- 1.5.1.3 The Owner and Consultant will conduct one Total Performance inspection and maximum one follow-up inspection. Subsequent inspections due to the Contractor's failure to complete work as required shall be paid for by the Contractor.
- 1.5.1.4 Failure of the Contractor to correct the listed deficiencies within the 40-day lien period will result in direct action being taken by the Owner to correct the deficiencies outside of the Contract.
- 1.5.1.5 On the 40th day of the lien period final inspection shall be made to ascertain that Contractor progresses with deficiencies and to invoke the above clause should it be required.
- 1.5.1.6 Once all deficiencies are complete and all parties are satisfied that the conditions are met for "Final Acceptance". The Owner, Contractor, and Consultant will all sign the **Project Close Out Final Acceptance Form**.

1.6 DEMONSTRATION AND TRAINING

- 1.6.1 The Owner's facility staff, shall receive orientation and training on features, systems and equipment in each facility requisite with the complexity and criticality of the system and the OWNER's needs.
- 1.6.2 Additional training requirements may be found in specific sections of Division 25.

1.7 FINAL CLEANING

- 1.7.1 Clean all workspace in accordance in anticipation of final turn-over
- 1.7.2 Remove surplus materials, excess materials, rubbish, tools and equipment.
- 1.7.3 Waste Management: separate waste materials for recycling

Part 2 Products

- 2.1 NOT USED

Part 3 Execution

- 3.1 NOT USED

END OF SECTION 01 77 00

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CLOSEOUT SUBMITTALS

Part 1 General

1.1 RELATED REQUIREMENTS

- 1.1.1 Section 01 33 00 - Submittal Procedures
- 1.1.2 Section 01 77 00 - Close-Out Procedures
- 1.1.3 Section 01 79 00 - Demonstration and Training.

1.2 REFERENCES

- 1.2.1 None

1.3 ADMINISTRATIVE REQUIREMENTS

- 1.3.1 Pre-warranty Meeting:
 - 1.3.1.1 Convene meeting one week prior to contract completion with contractor's representative and Owner's Authorized Representative to:
 - 1.3.1.1.1 Verify Project requirements.
 - 1.3.1.1.2 Review manufacturer's O&M instructions and warranty requirements.
 - 1.3.1.2 Owner's Authorized Representative to establish communication procedures for:
 - 1.3.1.2.1 Notifying of any construction warranty defects.
 - 1.3.1.2.2 Determine priorities for type of defects.
 - 1.3.1.2.3 Determine reasonable response time.
 - 1.3.1.3 Contact information for bonded and licensed company for warranty work action: provide name, telephone number and address of company authorized for construction warranty work action.
 - 1.3.1.4 Ensure contact is located within local service area of warranted construction, is continuously available, and is responsive to inquiries for warranty work action.

1.4 ACTION AND INFORMATIONAL SUBMITTALS

- 1.4.1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.2 Two weeks prior to Substantial Performance of the Work, submit to the Consultant, four (4) final copies of operating and maintenance manuals in English.
- 1.4.3 Provide spare parts, maintenance materials and special tools of same quality and manufacture as products provided in Work.
- 1.4.4 Provide evidence, if requested, for type, source and quality of products supplied.

1.5 FORMAT

- 1.5.1 Organize data as instructional manual.
- 1.5.2 Binders: vinyl, hard covered, 3 'D' ring, loose leaf 219 x 279 mm with spine and face pockets.
- 1.5.3 When multiple binders are used correlate data into related consistent groupings.
 - 1.5.3.1 Identify contents of each binder on spine.

CLOSEOUT SUBMITTALS

- 1.5.4 Cover: identify each binder with type or printed title 'Project Record Documents'; list title of project and identify subject matter of contents.
- 1.5.5 Arrange content by systems, under Section numbers and sequence of Table of Contents.
- 1.5.6 Provide tabbed fly leaf for each separate product and system, with typed description of product and major component parts of equipment.
- 1.5.7 Text: manufacturer's printed data, or typewritten data.
- 1.5.8 Drawings: provide with reinforced punched binder tab.
 - 1.5.8.1 Bind in with text; fold larger drawings to size of text pages.
- 1.5.9 Provide scaled CAD files in dwg format on CD.

1.6 CONTENTS - PROJECT RECORD DOCUMENTS

- 1.6.1 Table of Contents for Each Volume: provide title of project;
 - 1.6.1.1 Date of submission; List names and Date.
 - 1.6.1.2 Addresses, and telephone numbers of Consultant and Contractor with name of responsible parties.
 - 1.6.1.3 Schedule of products and systems indexed to content of volume.
- 1.6.2 For each product or system:
 - 1.6.2.1 List names, addresses and telephone numbers of subcontractors and suppliers, including local source of supplies and replacement parts.
- 1.6.3 Product Data: mark each sheet to identify specific products and component parts, and data applicable to installation; delete inapplicable information.
- 1.6.4 Drawings: supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams.
- 1.6.5 Typewritten Text: as required to supplement product data.
 - 1.6.5.1 Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions specified in Section 01 45 00 - Quality Control.
- 1.6.6 Training: refer to Section 01 79 00 - Demonstration and Training.

1.7 AS -BUILT DOCUMENTS AND SAMPLES

- 1.7.1 Maintain, at site for Consultant and Owner one record copy of:
 - 1.7.1.1 Contract Drawings.
 - 1.7.1.2 Specifications.
 - 1.7.1.3 Addenda.
 - 1.7.1.4 Change Orders and other modifications to Contract.
 - 1.7.1.5 Reviewed shop drawings, product data, and samples.
 - 1.7.1.6 Field test records.
 - 1.7.1.7 Inspection certificates.
 - 1.7.1.8 Manufacturer's certificates.
- 1.7.2 Store record documents and samples in field office apart from documents used for construction.
 - 1.7.2.1 Provide files, racks, and secure storage.

CLOSEOUT SUBMITTALS

- 1.7.3 Label record documents and file in accordance with Section number listings in List of Contents of this Project Manual.
 - 1.7.3.1 Label each document "PROJECT RECORD" in neat, large, printed letters.
- 1.7.4 Maintain record documents in clean, dry and legible condition.
 - 1.7.4.1 Do not use record documents for construction purposes.
- 1.7.5 Keep record documents and samples available for inspection by Consultant.

1.8 RECORDING INFORMATION ON PROJECT RECORD DOCUMENTS

- 1.8.1 Record information on set black line opaque drawings, and in copy of Project Manual, provided by Consultant.
- 1.8.2 Use felt tip marking pens, maintaining separate colours for each major system, for recording information.
- 1.8.3 Record information concurrently with construction progress.
 - 1.8.3.1 Do not conceal Work until required information is recorded.
- 1.8.4 Contract Drawings and shop drawings: mark each item to record actual construction, including:
 - 1.8.4.1 Measured depths of elements of foundation in relation to finish first floor datum.
 - 1.8.4.2 Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
 - 1.8.4.3 Measured locations of internal utilities and appurtenances referenced to visible and accessible features of construction.
 - 1.8.4.4 Field changes of dimension and detail.
 - 1.8.4.5 Changes made by change orders.
 - 1.8.4.6 Details not on original Contract Drawings.
 - 1.8.4.7 References to related shop drawings and modifications.
- 1.8.5 Specifications: mark each item to record actual construction, including:
 - 1.8.5.1 Manufacturer, trade name, and catalogue number of each product actually installed, particularly optional items and substitute items.
 - 1.8.5.2 Changes made by Addenda and change orders.
- 1.8.6 Other Documents: maintain manufacturer's certifications, inspection certifications, field test records, required by individual specifications sections.
- 1.8.7 Provide digital photos, if requested, for site records.

1.9 EQUIPMENT AND SYSTEMS

- 1.9.1 For each item of equipment and each system include description of unit or system, and component parts.
 - 1.9.1.1 Give function, normal operation characteristics and limiting conditions.
 - 1.9.1.2 Include performance curves, with engineering data and tests, and complete nomenclature and commercial number of replaceable parts.
- 1.9.2 Panel board circuit directories: provide electrical service characteristics, controls, and communications.

CLOSEOUT SUBMITTALS

- 1.9.3 Include installed colour coded wiring diagrams.
- 1.9.4 Operating Procedures: include start-up, break-in, and routine normal operating instructions and sequences.
 - 1.9.4.1 Include regulation, control, stopping, shut-down, and emergency instructions.
 - 1.9.4.2 Include summer, winter, and any special operating instructions.
- 1.9.5 Maintenance Requirements: include routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.
- 1.9.6 Provide servicing and lubrication schedule, and list of lubricants required.
- 1.9.7 Include manufacturer's printed operation and maintenance instructions.
- 1.9.8 Include sequence of operation by controls manufacturer.
- 1.9.9 Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
- 1.9.10 Provide installed control diagrams by controls manufacturer.
- 1.9.11 Provide Contractor's co-ordination drawings, with installed colour coded piping diagrams.
- 1.9.12 Provide charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
- 1.9.13 Provide list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.
- 1.9.14 Additional requirements: as specified in individual specification sections.

1.10 MATERIALS AND FINISHES

- 1.10.1 Building products, applied materials, and finishes: include product data, with catalogue number, size, composition, and colour and texture designations.
 - 1.10.1.1 Provide information for re-ordering custom manufactured products.
- 1.10.2 Instructions for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
- 1.10.3 Moisture-protection and weather-exposed products: include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
- 1.10.4 Additional requirements: as specified in individual specifications sections.

1.11 MAINTENANCE MATERIALS

- 1.11.1 Spare Parts:
 - 1.11.1.1 Provide spare parts, in quantities specified in individual specification sections.
 - 1.11.1.2 Provide items of same manufacture and quality as items in Work.
 - 1.11.1.3 Deliver to site; place and store.
 - 1.11.1.4 Receive and catalogue items.

CLOSEOUT SUBMITTALS

- 1.11.1.5 Submit inventory listing to Owner's Authorized Representative.
- 1.11.1.6 Include approved listings in Maintenance Manual.
- 1.11.1.7 Obtain receipt for delivered products and submit prior to final payment.
- 1.11.2 Extra Stock Materials:
 - 1.11.2.1 Provide maintenance and extra materials, in quantities specified in individual specification sections.
 - 1.11.2.2 Provide items of same manufacture and quality as items in Work.
 - 1.11.2.3 Deliver to site; place and store.
 - 1.11.2.4 Receive and catalogue items.
 - 1.11.2.5 Submit inventory listing to Owner's Authorized Representative.
 - 1.11.2.6 Include approved listings in Maintenance Manual.
 - 1.11.2.7 Obtain receipt for delivered products and submit prior to final payment.
- 1.11.3 Special Tools:
 - 1.11.3.1 Provide special tools, in quantities specified in individual specification section.
 - 1.11.3.2 Provide items with tags identifying their associated function and equipment.
 - 1.11.3.3 Deliver to site; place and store.
 - 1.11.3.4 Receive and catalogue items.
 - 1.11.3.5 Submit inventory listing to Owner's Authorized Representative.
 - 1.11.3.6 Include approved listings in Maintenance Manual.

1.12 DELIVERY, STORAGE AND HANDLING

- 1.12.1 Store spare parts, maintenance materials, and special tools in manner to prevent damage or deterioration.
- 1.12.2 Store in original and undamaged condition with manufacturer's seal and labels intact.
- 1.12.3 Store components subject to damage from weather in weatherproof enclosures.
- 1.12.4 Store paints and freezable materials in a heated and ventilated room.
- 1.12.5 Remove and replace damaged products at own expense and for review by Consultant.

1.13 WARRANTIES AND BONDS

- 1.13.1 Develop warranty management plan to contain information relevant to Warranties.
- 1.13.2 Submit warranty management plan, 30 days before planned pre-warranty conference, to Owner's Authorized Representative approval.
- 1.13.3 Warranty management plan to include required actions and documents to assure that Owner's Authorized Representative receives warranties to which it is entitled.
- 1.13.4 Provide plan in narrative form and contain sufficient detail to make it suitable for use by future maintenance and repair personnel.
- 1.13.5 Submit, warranty information made available during construction phase, to Owner's Authorized Representative for approval prior to each monthly pay estimate.

CLOSEOUT SUBMITTALS

- 1.13.6 Assemble approved information in binder, submit upon acceptance of work and organize binder as follows:
 - 1.13.6.1 Separate each warranty or bond with index tab sheets keyed to Table of Contents listing.
 - 1.13.6.2 List subcontractor, supplier, and manufacturer, with name, address, and telephone number of responsible principals.
 - 1.13.6.3 Obtain warranties and bonds, executed in duplicate by subcontractors, suppliers, and manufacturers, within ten days after completion of applicable item of work.
 - 1.13.6.4 Verify that documents are in proper form, contain full information, and are notarized.
 - 1.13.6.5 Co-execute submittals when required.
 - 1.13.6.6 Retain warranties and bonds until time specified for submittal.
- 1.13.7 Except for items put into use with Owner's permission, leave date of beginning of time of warranty until Date of Substantial Performance is determined.
- 1.13.8 Conduct joint 4 month and 9-month warranty inspection, measured from time of acceptance, by Owner's Authorized Representative.
- 1.13.9 Include information contained in warranty management plan as follows:
 - 1.13.9.1 Roles and responsibilities of personnel associated with warranty process, including points of contact and telephone numbers within the organizations of Contractors, subcontractors, manufacturers or suppliers involved.
 - 1.13.9.2 Provide list for each warranted equipment, item, feature of construction or system indicating:
 - 1.13.9.2.1 Name of item.
 - 1.13.9.2.2 Model and serial numbers.
 - 1.13.9.2.3 Location where installed.
 - 1.13.9.2.4 Name and phone numbers of manufacturers or suppliers.
 - 1.13.9.2.5 Names, addresses and telephone numbers of sources of spare parts.
 - 1.13.9.2.6 Warranties and terms of warranty: include one-year overall warranty of construction. Indicate items that have extended warranties and show separate warranty expiration dates.
 - 1.13.9.2.7 Cross-reference to warranty certificates as applicable.
 - 1.13.9.2.8 Starting point and duration of warranty period.
 - 1.13.9.2.9 Summary of maintenance procedures required to continue warranty in force.
 - 1.13.9.2.10 Cross-Reference to specific pertinent Operation and Maintenance manuals.
 - 1.13.9.2.11 Organization, names and phone numbers of persons to call for warranty service.
 - 1.13.9.2.12 Typical response time and repair time expected for various warranted equipment.
 - 1.13.9.3 Contractor's plans for attendance at 4- and 9-month post-construction warranty inspections.

CLOSEOUT SUBMITTALS

- 1.13.9.4 Procedure and status of tagging of equipment covered by extended warranties.
- 1.13.9.5 Post copies of instructions near selected pieces of equipment where operation is critical for warranty and/or safety reasons.
- 1.13.10 Respond in timely manner to oral or written notification of required construction warranty repair work.
- 1.13.11 Written verification to follow oral instructions.
 - 1.13.11.1 Failure to respond will be cause for the Owner's Authorized Representative to proceed with action against Contractor.

1.14 WARRANTY TAGS

- 1.14.1 Tag, at time of installation, each warranted item. Provide durable, oil and water-resistant tag approved by Owner's Authorized Representative.
- 1.14.2 Attach tags with copper wire and spray with waterproof silicone coating.
- 1.14.3 Leave date of acceptance until project is accepted for occupancy.
- 1.14.4 Indicate following information on tag:
 - 1.14.4.1 Type of product/material.
 - 1.14.4.2 Model number.
 - 1.14.4.3 Serial number.
 - 1.14.4.4 Contract number.
 - 1.14.4.5 Warranty period.
 - 1.14.4.6 Inspector's signature.
 - 1.14.4.7 Construction Contractor.

Part 2 Products

2.1 NOT USED

- 2.1.1 Not Used.

Part 3 Execution

3.1 NOT USED

- 3.1.1 Not Used.

END OF SECTION 01 78 00

DEMONSTRATION AND TRAINING

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1.2	ADMINISTRATIVE REQUIREMENTS.....	2
1.3	ACTION AND INFORMATIONAL SUBMITTALS.....	2
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Part 2	Products.....	3
2.1	NOT USED	3
Part 3	Execution	3
3.1	NOT USED	3

DEMONSTRATION AND TRAINING

Part 1 General

1.1 RELATED REQUIREMENTS

- 1.1.1 25 01 11 EMCS Start-Up, Verification and Commissioning
- 1.1.2 25 01 12 EMCS Training.

1.2 ADMINISTRATIVE REQUIREMENTS

- 1.2.1 Demonstrate the operation and maintenance of equipment and systems to Owner's personnel in accordance with sections 25 01 11 and 25 01 12.
- 1.2.2 Owner: provide list of personnel to receive instructions, and co-ordinate their attendance at agreed-upon times.
- 1.2.3 Preparation:
 - 1.2.3.1 Verify conditions for demonstration and instructions comply with requirements.
 - 1.2.3.2 Verify designated personnel are present.
 - 1.2.3.3 Ensure equipment has been inspected and put into operation in accordance with Section 25 01 11.
 - 1.2.3.4 Ensure testing, adjusting, and balancing has been performed and equipment and systems are fully operational.
- 1.2.4 Demonstration and Instructions:
 - 1.2.4.1 Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, and maintenance of each item of equipment at agreed upon times, at the designated location.
 - 1.2.4.2 Instruct personnel in phases of operation and maintenance using operation and maintenance manuals as basis of instruction.
 - 1.2.4.3 Review contents of manual in detail to explain aspects of operation and maintenance.
 - 1.2.4.4 Prepare and insert additional data in operations and maintenance manuals when needed during instructions.
- 1.2.5 Time Allocated for Instructions: ensure amount of time required for instruction of each item of equipment or system as follows:
 - 1.2.5.1 Section 25 01 12 - EMCS Training: refer to part 1.4 of Section 25 01 12 for details.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

- 1.3.1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- 1.3.2 Submit schedule of time and date for demonstration of each item of equipment and each system two weeks prior to designated dates, for Owner's approval.
- 1.3.3 Submit reports within one week after completion of demonstration, that demonstration and instructions have been satisfactorily completed.
- 1.3.4 Give time and date of each demonstration, with list of persons present.
- 1.3.5 Provide copies of completed operation and maintenance manuals for use in demonstrations and instructions.

DEMONSTRATION AND TRAINING

1.4 QUALITY ASSURANCE

1.4.1 When specified in individual Sections requiring manufacturer to provide authorized representative to demonstrate operation of equipment and systems:

1.4.1.1 Instruct Owner's personnel.

1.4.1.2 Provide written report that demonstration and instructions have been completed.

Part 2 Products

2.1 NOT USED

Part 3 Execution

3.1 NOT USED

END OF SECTION 01 79 00

GENERAL COMMISSIONING REQUIREMENTS

Part 1 General 2

 1.1 SUMMARY 2

 1.2 ACRONYMS: 2

 1.3 RELATED SECTION 2

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 1.6 OBJECTIVES 3

 1.7 COMMISSIONING (CX) OVERVIEW 3

 1.8 NON-CONFORMANCE TO PERFORMANCE VERIFICATION REQUIREMENTS 4

 1.9 PRE-CX REVIEW 4

Part 2 Products 5

 2.1 Not Used 5

Part 3 Execution 5

 3.1 Not Used 5

GENERAL COMMISSIONING REQUIREMENTS

Part 1 General

1.1 SUMMARY

- 1.1.1 Section Includes:
- 1.1.2 General requirements relating to commissioning of project's components and systems, specifying general requirements to PV of components, equipment, sub-systems, systems, and integrated systems.

1.2 ACRONYMS:

- 1.2.1 BMM - Building Management Manual.
- 1.2.2 Cx - Commissioning.
- 1.2.3 EMCS - Energy Monitoring and Control Systems.
- 1.2.4 O&M - Operation and Maintenance.
- 1.2.5 PI - Product Information.
- 1.2.6 PV - Performance Verification.
- 1.2.7 TAB - Testing, Adjusting and Balancing.

1.3 RELATED SECTION

- 1.3.1 Section 25 01 11 EMCS Start-Up, Verification and Commissioning
- 1.3.2 Section 25 01 12 EMCS Training
- 1.3.3 Section 25 90 01 EMCS Site Requirements Applications and System Sequences of Operation

1.4 GENERAL

- 1.4.1 Cx is a planned program of tests, procedures and checks carried out systematically on systems and integrated systems of the finished Project. Cx is performed after systems and integrated systems are completely installed, functional and Contractor's Performance Verification responsibilities have been completed and approved.
- 1.4.2 Objectives:
 - 1.4.2.1 Verify installed equipment, systems and integrated systems operate in accordance with Contract Documents and design criteria and intent.
 - 1.4.2.2 Ensure appropriate documentation is compiled into the BMM.
 - 1.4.2.3 Effectively train O&M staff.
- 1.4.3 Contractor assists in Cx process, operating equipment, and systems, troubleshooting and adjusting as required.
 - 1.4.3.1 Systems to be operated at full capacity under various modes to determine if they function correctly and consistently at peak efficiency. Systems to be interactively with each other as intended in accordance with Contract Documents and design criteria.
 - 1.4.3.2 During these checks, adjustments to be made to enhance performance to meet environmental or user requirements.

GENERAL COMMISSIONING REQUIREMENTS

- 1.4.4 Design Criteria: as per client's requirements or determined by designer. To meet Project functional and operational requirements.

1.5 SCOPE OF WORK

- 1.5.1 Provide all material, tools, labour, and supervision necessary to assist the commissioning agent in the verification of commissioning of the equipment and systems as outlined in the drawings, specifications, and final commissioning plan.
- 1.5.2 Contractors and Manufacturer Representative are to participate in the commissioning process and cooperate fully with the Commissioning Agent.
- 1.5.3 Once the contractor's commissioning is completed as outlined in the project specific Contract Documents, provide material, tools, labour and supervision to verify in detail with the CxA that the equipment and systems have been commissioned in accordance with this and related Sections.

1.6 OBJECTIVES

- 1.6.1 Verify installed equipment, systems and integrated systems operate in accordance with the owner's project requirements, the contract documents and design criteria and intent.
- 1.6.2 A third-party commissioning agent will perform commissioning verification of the new equipment and control sequences. This will include functional performance testing activities as outlined in the Final Commissioning Plan.
- 1.6.3 Contractor participates in the commissioning process, operating equipment and systems, troubleshooting and making adjustments as required.
- 1.6.4 Systems to be operated at full capacity under various modes to determine if they function correctly and consistently at peak efficiency. Systems to be operated interactively with each other as intended in accordance with contract documents and design criteria.
- 1.6.5 During these checks, adjustments to be made to enhance performance to meet environmental or user requirements.
- 1.6.6 A Final Commissioning Plan, including functional performance test forms, will be provided by the commissioning agent for completion by the contractor. The functional performance test forms will be based on the sequence of operations outlined in Section 25 90 01 EMCS Site Requirements Applications and System Sequences of Operation.

1.7 COMMISSIONING (CX) OVERVIEW

- 1.7.1 Complete commissioning scope to be defined by consultant/BAS Designer in project specific specifications (refer to Section 01 91 13.13 Commissioning Plan of project specifications).
- 1.7.2 Cx activities supplement field quality and testing procedures described in relevant technical sections.
- 1.7.3 Refer to drawings and specifications for overview of the equipment and systems to be commissioned. Final equipment and systems list will be provided in Final Commissioning Plan.

GENERAL COMMISSIONING REQUIREMENTS

- 1.7.4 Cx activities supplement field quality and testing procedures described in relevant technical sections of the Contract Documents. Cx activities do not relieve the Contractor from the contractual requirements outlined in other specification sections of the Contract Documents. Cx activities do not circumvent or relieve the Contractor from warranty requirements, responsibilities, or obligations.
- 1.7.5 Ensure all systems have been started, adjusted to design criteria, and are functionally operational, ready for independent testing. The CxA will not begin Functional Performance Testing until satisfied that all requirements have been met. The CxA reserves right to request inspection reports and sign-off from Contractor or Consultant that equipment and systems are ready for Functional Performance Testing.
- 1.7.6 Employ experienced personnel for equipment start up and commissioning, who are able to interpret results of readings and tests and report the system status in a clear and concise manner.
- 1.7.7 Provide all equipment required to perform testing, balancing, and commissioning of systems. Calibrate instruments used in start-up; provide calibration certificates if requested by the CxA.
- 1.7.8 Utilize equipment check certificates and other commissioning documents required by the CxA.
- 1.7.9 Verify that equipment is installed in accordance with Contract Documents, and reviewed shop drawings.
- 1.7.10 Commissioning will be considered complete once:
 - 1.7.10.1 Require start-up documentation and checklists, as outlined in Contract Documents, have been submitted for review by the CxA.
 - 1.7.10.2 Completed Cx documentation has been received, reviewed for suitability and approved by the CxA and the Owner.
 - 1.7.10.3 Equipment, components, and systems have been commissioned and all issues have been addressed to the satisfaction of the Owner.

1.8 NON-CONFORMANCE TO PERFORMANCE VERIFICATION REQUIREMENTS

- 1.8.1 Should equipment, system components, and associated controls be incorrectly installed or malfunction during Cx, correct deficiencies, re-verify equipment and components within the non-functional system, including related systems as deemed required by the CxA to ensure effective performance.
- 1.8.2 Costs for corrective work, additional tests and inspections to determine acceptability and proper performance of such items to be borne by the Contractor. Above costs to be in the form of progress payment reductions or hold-back assessments.

1.9 PRE-CX REVIEW

- 1.9.1 Before Construction:
 - 1.9.1.1 Review contract documents confirm by writing to Consultant.
 - 1.9.1.1.1 Adequacy of provisions for Cx.
 - 1.9.1.1.2 Aspects of design and installation pertinent to success of Cx.
- 1.9.2 During Construction:

GENERAL COMMISSIONING REQUIREMENTS

- 1.9.2.1 Co-ordinate provision, location, and installation of provisions for Cx.
- 1.9.3 Before start of Cx:
 - 1.9.3.1 Have completed Cx Plan up to date.
 - 1.9.3.2 Ensure installation of related components, equipment, sub-systems, systems is complete.
 - 1.9.3.3 Fully understand Cx requirements and procedures.
 - 1.9.3.4 Understand completely design criteria and intent and special features.
 - 1.9.3.5 All related equipment has been started up and start-up reports and pre-functional checklists are submitted and approved ready for functional testing.
 - 1.9.3.6 All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning, and sensor calibrations completed.
 - 1.9.3.7 Piping system flushing complete, water treatment system complete and operational.
 - 1.9.3.8 Vibration control report approved (if required).
 - 1.9.3.9 Test and balance (TAB) complete and approved for the air and hydronic systems.
 - 1.9.3.10 All A/E deficiency list items for the equipment specified are corrected.
 - 1.9.3.11 Functional test procedures have been reviewed and approved by installing contractor.
 - 1.9.3.12 Safeties and operating ranges reviewed by the CxA and the Contractor.
 - 1.9.3.13 Test requirements and sequences of operation provided.
 - 1.9.3.14 Schedules and setpoints provided.
 - 1.9.3.15 False loading equipment, system, and procedures ready.
 - 1.9.3.16 Crankcase heaters have been on long enough for start-up.
 - 1.9.3.17 Sufficient clearance around equipment for servicing.
 - 1.9.3.18 Record of all values for pre-test setpoints changed to accommodate testing has been made and a check box provided to verify return to original values (control parameters, limits, delays, lockouts, schedules, etc.)
 - 1.9.3.19 Other miscellaneous checks of the pre-functional checklist and start-up reports completed successfully.
 - 1.9.3.20 Points verification report from Control Contractor has been provided.
- 1.9.4 Inform Consultant in writing of discrepancies and deficiencies on finished works.

Part 2 Products

2.1 Not Used

Part 3 Execution

3.1 Not Used

END OF SECTION 01 45 00

DEMOLITION FOR MINOR WORKS

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Part 3	Execution	2
3.1	EXAMINATION	2
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DEMOLITION FOR MINOR WORKS

Part 1 General

1.1 RELATED REQUIREMENTS

1.1.1 N/A

1.2 REFERENCES

1.2.1 CSA International

1.2.1.1 CSA S350, Code of Practice for Safety in Demolition of Structures.

1.2.2 U.S. Environmental Protection Agency (EPA)/Office of Water

1.2.2.1 EPA 832/R-92-005, Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

1.3.1 N/A

1.4 SITE CONDITIONS

1.4.1 Review "Designated Substance Report" and take precautions to protect environment.

1.4.2 If material resembling spray or trowel-applied asbestos or other designated substance listed as hazardous be encountered, stop work, take preventative measures, and notify Owner & Consultant immediately.

1.4.2.1 Proceed only after receipt of written instructions have been received from Consultant.

1.4.3 Notify Owner and Consultant before disrupting building access or services including Power, Water, Life Safety, and Environmental Controls.

Part 2 Products

2.1 NOT USED

2.1.1 Not used.

Part 3 Execution

3.1 EXAMINATION

3.1.1 Inspect building with Owner's Authorized Representative (OAR) and verify extent and location of items designated for removal, disposal, alternative disposal, recycling, salvage and items to remain.

3.1.2 Locate and protect utilities. Preserve active utilities traversing site in operating condition.

3.1.3 Notify and obtain approval of utility companies before starting demolition.

3.1.4 Disconnect, cap, plug or divert, as required, existing public utilities within the property where they interfere with the execution of the work, in conformity with the

DEMOLITION FOR MINOR WORKS

requirements of the authorities having jurisdiction. Mark the location of these and previously capped or plugged services on the site and indicate location (horizontal and vertical) on the record drawings. Support, shore up, and maintain pipes and conduits encountered.

- 3.1.4.1 Immediately notify OAR, Consultant and utility company concerned in case of damage to any utility or service, designated to remain in place.
- 3.1.4.2 Immediately notify the OAR and Consultant should uncharted utility or service be encountered and await instruction in writing regarding remedial action.

3.2 PREPARATION

3.2.1 Protection of In-Place Conditions:

- 3.2.1.1 Keep noise, dust, and inconvenience to occupants to minimum.
- 3.2.1.2 Protect building systems, services and equipment.
- 3.2.1.3 Provide temporary dust screens, covers, railings, supports and other protection as required.

3.2.2 Demolition/Removal:

- 3.2.2.1 Remove all existing redundant controls and control devices and other items as indicated. Where specifically identified in specifications or points list, return to owner. If not specified, dispose of in environmentally friendly manner.
- 3.2.2.2 Remove/relocate existing services as required to permit new construction.

3.3 CLEANING

3.3.1 Progress Cleaning:

- 3.3.1.1 Leave Work area clean at end of each day.

3.3.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment from site.

- 3.3.3 Refer to demolition drawings and project specifications for items to be salvaged for reuse.

END OF SECTION 02 41 99

FIRE STOPPING

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FIRE STOPPING

Part 1 General

1.1 RELATED SECTIONS

- 1.1.1 Section 25 05 01 EMCS General Requirements
- 1.1.2 Section 25 30 02 EMCS Field Control Devices
- 1.1.3 Section 26 05 00 Common Work Results Electrical.

1.2 REFERENCES

- 1.2.1 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
- 1.2.2 Material Safety Data Sheets (MSDS).
- 1.2.3 Underwriter's Laboratories of Canada (ULC)
- 1.2.4 ULC-S115, Fire Tests of Fire stop Systems.

1.3 DEFINITIONS

- 1.3.1 Fire Stop Material: device intended to close off opening or penetration during fire or materials that fill openings in wall or floor assembly where penetration is by cables, cable trays, conduits, ducts and pipes and poke-through termination devices, including electrical outlet boxes along with their means of support through wall or floor openings.
- 1.3.2 Single Component Fire Stop System: fire stop material that has Listed Systems Design and is used individually without use of high temperature insulation or other materials to create fire stop system.
- 1.3.3 Multiple Component Fire Stop System: exact group of fire stop materials that are identified within Listed Systems Design to create on site fire stop system.
- 1.3.4 Tightly Fitted; (ref: NBC Part 3.1.9.1.1 and 9.10.9.6.1): penetrating items that are cast in place in buildings of non-combustible construction or have "0" annular space in buildings of combustible construction.
 - 1.3.4.1 Words "tightly fitted" should ensure that integrity of fire separation is such that it prevents passage of smoke and hot gases to unexposed side of fire separation.

1.4 SUBMITTALS

- 1.4.1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.2 Product Data:
 - 1.4.2.1 Submit manufacturer's printed product literature, specifications and datasheet and include product characteristics, performance criteria, physical size, finish and limitations.
 - 1.4.2.2 Submit two copies of WHMIS MSDS - Material Safety Data Sheets.
- 1.4.3 Shop Drawings:
 - 1.4.3.1 Submit shop drawings to show proposed material, reinforcement, anchorage, fastenings and method of installation.
 - 1.4.3.2 Construction details should accurately reflect actual job conditions.

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- 1.4.4 Samples:
 - 1.4.4.1 Submit duplicate 300 x 300 mm samples showing actual fire stop material proposed for project.
- 1.4.5 Quality assurance submittals: submit following in accordance with Section 01 45 00 - Quality Control.
 - 1.4.5.1 Test reports: in accordance with CAN-ULC-S101 for fire endurance and CAN-ULC-S102 for surface burning characteristics.
- 1.4.5.1.1 Submit certified test reports from approved independent testing laboratories, indicating compliance of applied fire stopping with specifications for specified performance characteristics and physical properties.
 - 1.4.5.2 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.4.5.3 Manufacturer's Instructions: submit manufacturer's installation instructions and special handling criteria, installation sequence, and cleaning procedures.
 - 1.4.5.4 Manufacturer's Field Reports: Where requested by consultant, submit to manufacturer's written reports within 3 days of review, verifying compliance of Work, as described in PART 3 - FIELD QUALITY CONTROL.

1.5 QUALITY ASSURANCE

- 1.5.1 Qualifications:
 - 1.5.1.1 Installer: person specializing in fire stopping installations with [2] years documented experience or approved by manufacturer (in writing).
- 1.5.2 Pre-Installation Meetings: convene pre-installation meeting prior to beginning work of this Section, with EMCS contractor's representative to:
 - 1.5.2.1 Verify project requirements.
 - 1.5.2.2 Review installation and substrate conditions.
 - 1.5.2.3 Co-ordination with other building subtrades.
 - 1.5.2.4 Review manufacturer's installation instructions and warranty requirements.
- 1.5.3 Site Meetings: as part of Manufacturer's Services described in PART 3 - FIELD QUALITY CONTROL, schedule site visits, to review Work, at stages listed.
 - 1.5.3.1 After delivery and storage of products, and when preparatory Work is complete, but before installation begins.
 - 1.5.3.2 Once during progress of Work at 25%.
 - 1.5.3.3 Upon completion of Work, after cleaning is carried out.

1.6 DELIVERY, STORAGE AND HANDLING

- 1.6.1 Packing, shipping, handling and unloading:
 - 1.6.1.1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

FIRE STOPPING

- 1.6.1.2 Deliver materials to the site in undamaged condition and in original unopened containers, marked to indicate brand name, manufacturer, ULC markings.
- 1.6.2 Storage and Protection:
 - 1.6.2.1 Store materials indoors and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - 1.6.2.2 Replace defective or damaged materials with new.
- 1.6.3 Waste Management and Disposal:
 - 1.6.3.1 Separate waste materials for recycling where applicable.

Part 2 Products

2.1 MATERIALS

- 2.1.1 Fire stopping and smoke seal systems: in accordance with CAN-ULC-S115.
 - 2.1.1.1 Asbestos-free materials and systems capable of maintaining effective barrier against flame, smoke and gases in compliance with requirements of CAN-ULC-S115 and not to exceed opening sizes for which they are intended [and conforming to specified special requirements described in PART 3.
 - 2.1.1.2 Fire stop system rating: Min 1 hr (or match existing where greater).
- 2.1.2 Service penetration assemblies: systems tested to CAN-ULC-S115.
- 2.1.3 Service penetration fire stop components: certified by test laboratory to CAN-ULC-S115.
- 2.1.4 Fire-resistance rating of installed fire stopping assembly in accordance with NBC.
- 2.1.5 Fire stopping and smoke seals at openings intended for ease of re-entry such as cables: elastomeric seal.
- 2.1.6 Fire stopping and smoke seals at openings around penetrations for pipes, ductwork and other mechanical items requiring sound and vibration control: elastomeric seal.
- 2.1.7 Primers: to manufacturer's recommendation for specific material, substrate, and end use.
- 2.1.8 Water (if applicable): potable, clean and free from injurious amounts of deleterious substances.
- 2.1.9 Damming and backup materials, supports and anchoring devices: to manufacturer's recommendations, and in accordance with tested assembly being installed as acceptable to authorities having jurisdiction.
- 2.1.10 Sealants for vertical joints: non-sagging.

FIRE STOPPING

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 PREPARATION

- 3.2.1 Examine sizes and conditions of voids to be filled to establish correct thicknesses and installation of materials.
 - 3.2.1.1 Ensure that substrates and surfaces are clean, dry and frost free.
- 3.2.2 Prepare surfaces in contact with fire stopping materials and smoke seals to manufacturer's instructions.
- 3.2.3 Maintain insulation around pipes and ducts penetrating fire separation [without interruption to vapour barrier.
- 3.2.4 Mask where necessary to avoid spillage and over coating onto adjoining surfaces; remove stains on adjacent surfaces.

3.3 INSTALLATION

- 3.3.1 Install fire stopping and smoke seal material and components in accordance with manufacturer's certified tested system listing.
- 3.3.2 Seal holes or voids made by through penetrations, poke-through termination devices, and unpenetrated openings or joints to ensure continuity and integrity of fire separation are maintained.
- 3.3.3 Provide temporary forming as required and remove forming only after materials have gained sufficient strength and after initial curing.
- 3.3.4 Tool or trowel exposed surfaces to neat finish.
- 3.3.5 Remove excess compound promptly as work progresses and upon completion.

3.4 SEQUENCES OF OPERATION

- 3.4.1 Proceed with installation only when submittals have been reviewed and approved by Consultant.
- 3.4.2 Install floor fire stopping before interior partition erections.
- 3.4.3 Metal deck bonding: fire stopping to precede spray applied fireproofing to ensure required bonding.
- 3.4.4 Mechanical pipe insulation: certified fire stop system component.
 - 3.4.4.1 Ensure pipe insulation installation precedes fire stopping.

3.5 FIELD QUALITY CONTROL

- 3.5.1 Inspections: notify Authority of Jurisdiction and Consultant when ready for inspection and prior to concealing or enclosing fire stopping materials and service penetration assemblies.

FIRE STOPPING

3.5.2 Manufacturer's Field Services:

- 3.5.2.1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - SUBMITTALS.
- 3.5.2.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
- 3.5.2.3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

3.6 CLEANING

- 3.6.1 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.
- 3.6.2 Remove temporary dams after initial set of fire stopping and smoke seal materials.

3.7 SCHEDULE

3.7.1 Fire stop and smoke seal at:

- 3.7.1.1 Penetrations through fire-resistance rated masonry, concrete, and gypsum board partitions and walls.
- 3.7.1.2 Edge of floor slabs at curtain wall and precast concrete panels.
- 3.7.1.3 Top of fire-resistance rated masonry and gypsum board partitions.
- 3.7.1.4 Intersection of fire-resistance rated masonry and gypsum board partitions.
- 3.7.1.5 Control and sway joints in fire-resistance rated masonry and gypsum board partitions and walls.
- 3.7.1.6 Penetrations through fire-resistance rated floor slabs, ceilings and roofs.
- 3.7.1.7 Openings and sleeves installed for future use through fire separations.
- 3.7.1.8 Around mechanical and electrical assemblies penetrating fire separations.
- 3.7.1.9 Rigid ducts: greater than 129 cm²: fire stopping to consist of bead of fire stopping material between retaining angle and fire separation and between retaining angle and duct, on each side of fire separation.

END OF SECTION 07 84 00

EMCS: START-UP, VERIFICATION AND COMMISSIONING

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EMCS: START-UP, VERIFICATION AND COMMISSIONING

Part 1 General

1.1 SUMMARY

1.1.1 Section Includes.

1.1.1.1 Methods and procedures for start-up, verification and commissioning, for building Energy Management Control System (EMCS) and includes:

- 1.1.1.1.1 Start-up testing and verification of systems.
- 1.1.1.1.2 Check out demonstration or proper operation of components.
- 1.1.1.1.3 On-site operational tests.

1.1.2 Related Sections.

- 1.1.2.1 Section 01 33 00 - Submittal Procedures.
- 1.1.2.2 Section 01 78 00 - Closeout Submittals.
- 1.1.2.3 Section 01 91 12 – General Commissioning Requirements
- 1.1.2.4 Section 01 79 00 – Demonstration and Training
- 1.1.2.5 Section 25 01 12 - EMCS: Training.
- 1.1.2.6 Section 25 05 01 - EMCS: General Requirements.

1.2 DEFINITIONS

1.2.1 For additional acronyms and definitions refer to Section 25 05 01 - General Requirements.

1.2.2 **AEL:** ratio between total test period less any system downtime accumulated within that period and test period.

1.2.3 **Downtime:** results whenever EMCS is unable to fulfill required functions due to malfunction of equipment defined under responsibility of EMCS vendor. Downtime is measured by duration, in time, between time that Vendor is notified of failure and time system is restored to proper operating condition. Downtime not to include following:

1.2.3.1 Outage of main power supply in excess of back-up power sources provided that:

- 1.2.3.1.1 Automatic initiation of back-up was accomplished.
- 1.2.3.1.2 Automatic shut-down and re-start of components was as specified.

1.2.3.2 Failure of communications link, provided that:

- 1.2.3.2.1 Controller automatically and correctly operated in stand-alone mode.
- 1.2.3.2.2 Failure was not due to failure of any specified EMCS equipment.

1.2.3.3 Functional failure resulting from individual sensor inputs or output devices provided that:

- 1.2.3.3.1 System recorded said fault.
- 1.2.3.3.2 Equipment defaulted to fail-safe mode.
- 1.2.3.3.3 AEL of total of all input sensors and output devices is at least 99% during test period.

EMCS: START-UP, VERIFICATION AND COMMISSIONING

1.3 SUBMITTALS

- 1.3.1 Functional Testing Check List (refer to Appendix B): Complete and submit to Commissioning Agent (CA), Consultant and Owner. See 1.6.2.
 - 1.3.1.1 Include measurements, final settings and certified test results.
 - 1.3.1.2 Bear signature of control technician responsible for completing verification
 - 1.3.1.3 Revise shop drawings to reflect changes, adjustments, and modifications to EMCS as set during construction and submit preliminary "as-built" to CA, Consultant and/or Owner in accordance with Section 01 78 00 - Closeout Submittals and Section 25 05 02 EMCS Submittals and Review Process.
 - 1.3.1.4 Recommend additional changes and/or modifications deemed advisable in order to improve performance, environmental conditions or energy consumption.

1.4 CLOSEOUT SUBMITTALS

- 1.4.1 Provide documentation, O&M Manuals, and training of O&M personnel for review of Consultant and Owner before interim acceptance in accordance with Section 01 78 00 Closeout Submittals.
- 1.4.2 Revise preliminary "as-built" documentation to final AS-BUILT documentation. Final AS-BUILT to reflect changes made during commissioning including but not limited to sequences, set-point and limit adjustments, and alarm settings.

1.5 DESIGN REQUIREMENTS(CA)

- 1.5.1 The CA shall Confirm with Consultant and/or Owners Authorized Representative that Design Criteria and Design Intents are still applicable.
- 1.5.2 CA to be fully aware of, and qualified to interpret Design Criteria and Design Intents.

1.6 PRE-COMMISSIONING

- 1.6.1 As a part of the EMCS installation, the vendor shall fully test and pre-commission the entire EMCS. All pre-commissioning activates shall be fully documented on the Functional Testing Check List (refer to Appendix B) and shall be submitted with the City of Mississauga **Project Close Out Provisional Acceptance Forms** *prior* to Demonstration and acceptance testing.
- 1.6.2 Pre- Commissioning shall include a point-to point verification of the following at the minimum:
 - 1.6.2.1 Verify that all Panel Enclosures, EMCS equipment, building and field controllers, end devices and sensors, are installed and operational according to the specifications, submittals and manufacturer's installation and application instructions.
 - 1.6.2.2 Test, calibrate and bring on-line every control device.
 - 1.6.2.3 Calibrate all inputs by comparing the actual site condition with the Graphical Interface point display.
 - 1.6.2.4 Verify all outputs from Graphical Interface command to observed response of controlled device.

EMCS: START-UP, VERIFICATION AND COMMISSIONING

- 1.6.2.5 Verify failure response and fail-safe conditions of all devices and safeties.
- 1.6.2.6 Each control program shall be fully commissioned and tested for complete design intent compliance and functionality.
- 1.6.2.7 Verify overall network performance of EMCS for complete design intent compliance and functionality with all devices on-line, communicating and fully operational.
- 1.6.2.8 Subsystems not directly controlled by the EMCS but associated with the OEM Application Specific Controllers (OEMASC) shall also be fully tested and commissioned as to design intent compliance and functionality.
- 1.6.3 Refer to 3.6 for additional details.

1.7 COMMISSIONING

- 1.7.1 Upon completion of the Pre-Commissioning, EMCS vendor shall provide full assistance, staff, and materials to support the commissioning activities. This includes:
 - 1.7.1.1 Provision of all testing apparatus in use by the vendor to test and calibrate or verify calibration of control system and all other apparatus for which the vendor has control or calibration responsibility.
 - 1.7.1.2 Assistance includes but is not limited to reviewing test procedures and providing software enhancements to accommodate testing methods.
 - 1.7.1.3 On-site programmer/control technician to carry out the operator commands and adjustments to software parameters as directed by the Owners designated Commissioning Agent (CA). This may include but is not limited to; physical inspection of all hardware installed, point-to point functional testing (also referred to as Owner-Witnessed Testing), and system Performance Verification Testing.

1.8 COMPLETION OF COMMISSIONING

- 1.8.1 Commissioning to be considered as satisfactorily completed when objectives of commissioning have been achieved and reviewed by CA, Consultant, and Owner's Project Manager or Designated Representative.
- 1.8.2 Vendor shall fill out the City of Mississauga **Project Closeout Provisional Acceptance Form** (refer to Appendix B) and submit for approval.

1.9 ISSUANCE OF FINAL CERTIFICATE OF COMPLETION

- 1.9.1 When Commissioning is complete the CA will issue a Commissioning Report documenting the results of the Functional and Performance Based Testing that occurred and identifying any system or installation deficiencies. This list of deficiencies will be added to the list previously attached to the Project Close Out Provisional Acceptance Form and then addressed by the contractor. The contractor will then work to complete all outstanding deficiencies in a timely manor and then submit with a signed copy of the **Project Closeout Final Acceptance Form** (refer to Appendix B). Once Accepted, the Consultant will issue Final Certificate of Completion. Refer to Part 3.11 for Acceptance Procedures.

EMCS: START-UP, VERIFICATION AND COMMISSIONING

Part 2 Products

2.1 EQUIPMENT

- 2.1.1 Not applicable

Part 3 Execution

3.1 PROCEDURES

- 3.1.1 Test each system independently and then in unison with other related systems.
- 3.1.2 Commission integrated systems using procedures prescribed by Consultant and or as specified within. It is the EMCS vendor's responsibility to coordinate with others to ensure a Control representative familiar with the programming and set-up of the integrated system being present to ensure all BACnet communication points are properly configured and visible to the EMCS including Read/Write privileges and that the specified sequence and integration is operating as intended.
- 3.1.3 Debug system software.
- 3.1.4 Optimize operation and performance of systems by fine-tuning PID values and modifying CDLs as required.

3.2 START-UP TRIALS

- 3.2.1 The Consultant may at any time be able to either, on his own, or demand from the Vendor a check of all the apparatus, system or installation.
- 3.2.2 This test does not constitute in any manner an acceptance and may not give way to any claim for compensation due to accident, damage or rupture as a result of any deficiency in the apparatus, equipment or installation.

3.3 FACTORY TESTING

- 3.3.1 All computers and controls shall have passed a verification test in the factory before delivery to the site.
- 3.3.2 Every circuit in the SRPDC RPDC & DDC shall have been tested and operated for a minimum period of at least 96 hours.

3.4 COMMISSIONING (OWNER-WITNESSED TESTING)

- 3.4.1 Testing the actual system installed on site shall be done in order to demonstrate the full functionality of the EMCS to the Owner's, Consultant's and/or Owner's Commissioning Agent's satisfaction. The Vendor shall supply the instruments, specialized tools and labour for the necessary adjustments in order to obtain the specified system performance.
- 3.4.2 Commissioning shall include both point-to-point (**Functional**) testing and control sequence verification (**Performance Testing**).

EMCS: START-UP, VERIFICATION AND COMMISSIONING

- 3.4.3 A local operator workstation (LOWS), including all necessary software shall be made available and utilized to support the point-to point **Functional Testing** and **Performance Testing** activities. As the installed system is intended to be accessible from any Owner designated workstation, the location of the LOWS will be defined by the Owner and/or Owner's Authorized Representative prior to the start of commissioning activities.
 - 3.4.3.1 Any LOWS connected upstream of the City of Mississauga demarcation point must meet all City of Mississauga ITS requirements and be approved for use by ITS.
- 3.4.4 After receipt of all system documentation (as supplied by this vendor) by the Owner and/or Owner's Authorized Representative, notify the Owner 10 working days before testing begins.
- 3.4.5 Testing shall be performed by the vendor, witnessed by the Owner or his appointed representative.
- 3.4.6 The vendor must fill out and complete the formatted **Functional Testing Check List** documentation (refer to Appendix B) for witnessing the results, comments, vendor repair activity, vendor's initials, and re-test witnessing. Vendor shall submit these **Functional Testing Check List** with one line for each physical point on the system, and columns to record the results, dates, and initials witnesses for both pre-tests and witness tests.
- 3.4.7 The Vendor shall perform pre-commissioning point-to-point verification (Functional Testing) before the witnessed tests and shall fill in the **Functional Testing Check List** to demonstrate successful performance prior to witness tests (refer to Appendix B for a sample copy of **Functional Testing Check List**). Electronic version of the check list shall be provided to the vendor at the start of the project with all intended/specified points listed by others during the design phase. The vendor shall complete remaining fields including point names, device ID, etc. as job progresses.

3.5 FUNCTIONAL TESTING

- 3.5.1 All items listed within this Section 3.5 shall be considered the minimum standard for functional testing to be completed.
- 3.5.2 Verify operation, location and proper identification of all power sources, including circuit breakers and control equipment power transformers.
- 3.5.3 Start/stop points:
 - 3.5.3.1 Issue start and stop commands from the local operator workstation (LOWS). Verify that controlled equipment responds appropriately and that the stat/stop status is accurately reflected at the (LOWS).
- 3.5.4 Analog points:
 - 3.5.4.1 Analog inputs and outputs shall be verified at both extremes of their ranges and at the midpoint. Verify tight shutoff and full opening of the dampers and valves.
- 3.5.5 Digital points:
 - 3.5.5.1 Verify that both commanded conditions (on/off, open/closed, etc.) and device status are accurately reflected at the LOWS.

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- 3.5.6 Fan and pump failure alarms:
 - 3.5.6.1 Test by turning off the motor at the Hand/Off/Auto (HOA) switch and observing the run-state indication at the operator station.
- 3.5.7 Temperature points:
 - 3.5.7.1 Verify accuracy of sensors by comparing temperature values with the reading of an independent measuring device located in the same space or flow. Test liquid temperature sensors as installed in piping thermo wells to verify effectiveness of heat conducting compound.
- 3.5.8 Pressure points:
 - 3.5.8.1 Verify accuracy of sensors by comparing displayed pressure with the reading of an independent measuring device located in the same flow stream. Retain the services of the balancer as required to confirm reading.
- 3.5.9 Control valves:
 - 3.5.9.1 Verify tight shutoff by comparing water or air temperature entering and leaving the heat transfer device.
- 3.5.10 Operator response and sequencing:
 - 3.5.10.1 Demonstrate that sequenced or modulated valves and dampers position accurately in response to changed conditions. Ensure that the positioned response accurately follows anticipated and specified control behavior. Ensure that the petition of multiple operators provides simultaneous modulation of damper or valve assemblies.
- 3.5.11 Control signal stability (general):
 - 3.5.11.1 Demonstrate the control loops are tuned so that the output does not change until the controlled system has time to respond to the last output signal.
- 3.5.12 Control signal stability (response to step input):
 - 3.5.12.1 Demonstrate that control loops are tuned so that they are stable without excessive hunting following a step input of not less than 20% of the operating/reset range of the controlled variable.
- 3.5.13 Control signal stability (floating point devices):
 - 3.5.13.1 Verify that minimum pulse output duration is no less than the value required to assure repositioning to the controlled device.
- 3.5.14 Demonstrate the capability of the controls system to execute the complete sequence of operation as given in the mechanical controls design documents.
- 3.5.15 Verify tight shut-off of all actuated control valves (for 3-way valves, demonstrate capacity for 100% by-pass of coil).
- 3.5.16 Failure modes
 - 3.5.16.1 Verify all stand-alone operation by disconnecting communication lines between stand-alone control units and verifying continued operation.
 - 3.5.16.2 Disconnect and reapply 120 VAC Local Operation Station (LOWS) power to confirm proper power recovery from power failure.

EMCS: START-UP, VERIFICATION AND COMMISSIONING

3.5.16.3 Disconnect and reconnect DDC controller power to confirm proper power recovery from power failure.

3.6 PERFORMANCE TESTING

- 3.6.1 Using the graphical interface at Local operator workstation (LOWS), and in conjunction with CA, verify the operation and functionality of the following:
- 3.6.2 Override test: Verify manual override capability for start/stop and modulated points types.
- 3.6.3 Control logic
 - 3.6.3.1 Exercise all control logic packages.
 - 3.6.3.2 Check response to change in set-point and/or key control parameters.
- 3.6.4 Supervisory functions
 - 3.6.4.1 Verify content of time clock schedules.
 - 3.6.4.2 Verify alarm's reporting capabilities including; establishing alarm limits, alarm priorities (i.e. – Critical, Maintenance, Energy, Out of Range, etc.), routing priorities .
 - 3.6.4.3 Demonstrate alarm routing functionality by triggering each different type of alarm and verifying that the system properly routed the alarm to the appropriate email and recorded in historical files, etc.
 - 3.6.4.4 Set-up and demonstrate trending and verify the location of data storage for historical trending.
 - 3.6.4.5 Verify Global commands.

3.7 CONTROLLER / CONTROLLER SYSTEM FAILURE MODE TESTING

- 3.7.1 Verify all stand-alone operation by disconnecting communication lines between stand-alone control units and verifying continued operation.
- 3.7.2 Disconnect and reapply 120 VAC Local Operation Station (LOWS) power to confirm proper power recovery from power failure.
- 3.7.3 Disconnect and reconnect controller power (to each controller) to confirm proper power recovery from power failure.

3.8 PARTIAL START-UP

- 3.8.1 The Vendor shall be ready for a partial start-up. The system may be started-up and functioning even though all the components are not yet installed. For example, the system may be started-up with only one SRPDC and one point and subsequently the rest of the points and other SRPDC can be added to the system and started-up.

3.9 SWITCH OVER OF EXISTING TO NEW SYSTEM (Control System Replacements and Upgrades)

- 3.9.1 Once the immediate work is completed, the new system shall operate and replace the old control system. The Vendor shall remove all pneumatic and electric controllers, relays, piping, switches, and panels etc. that are no longer required and shall hand

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them to the Owner. The pneumatic tubing connected to the existing pneumatic actuators may be reused if it is clean and not pierced.

- 3.9.2 The Vendor shall clean the site of all equipment that the Owner does not desire to keep. Equipment that the Owner wishes to keep will be identified and a list turned over to the vendor prior to the start of any demolition.
- 3.9.3 The existing equipment that allows starting and stopping the system locally with a key shall be conserved for added safety measures during maintenance work. These locks shall be transferred to the new panels if necessary. The whole shall be kept in good working order.
- 3.9.4 The existing local analog gauges shall not be retained, except for the differential static pressure gauge (D.S.P.G) inside the mechanical system that shall remain functional. These gauges (D.S.P.G.) shall be installed properly.
- 3.9.5 The sequences of operation for the fire alarm shall be respected and the vendor shall transfer to the new system all the necessary information from the existing panel. All transfers shall be done in parallel with the implementation of the system. The switchover from the old to the new system shall be done in a minimum downtime, subject to the Owner's approval. A temporary control system shall be provided by the Vendor during the power transfer.

3.10 DEMONSTRATION

- 3.10.1 Demonstration is not a part of Start-Up/Commissioning or training and shall be done independently and only after completion of both tasks.
- 3.10.2 Demonstrate to Consultant and Owner the operation of systems including a thorough review of the sequence of operations in regular and emergency modes, under normal and emergency conditions, start-up, shut-down interlocks and lockouts in accordance with Section 01 79 00 - Demonstration and Training.

3.11 ACCEPTANCE OF WORK

- 3.11.1 Real End of the Work
 - 3.11.1.1 The real end of work shall occur when all demolition, installations, programming and graphics are complete, and the Contractor has completed (their own) initial Functional and Performance Based testing and made arrangements with the Commissioning Agent to establish a date for commissioning. Any known deficiencies to that point of the project shall be documented by the contractor (on Provisional Acceptance Form) and then scheduled for completion prior to the start of Commissioning. To mark the real end of work, the contractor shall complete (and submit) a signed copy of the City of Mississauga **Project Close Out Provisional Acceptance Form** (and all closeout documentation) to signify that they are ready for a final inspection (and commissioning)
- 3.11.2 Provisional Acceptance
 - 3.11.2.1 The provisional acceptance shall follow the real end of the work and shall signal the contractor's readiness for the start of Commissioning.
 - 3.11.2.2 The Vendor shall complete and submit a signed copy of the **Project Close Out Provisional Acceptance Form** as their request for the provisional acceptance.

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This shall occur only when the system is completely installed, calibrated, tested and operational. The Owner's representative and Consultant will then conduct a final inspection of the installation and review all submitted close-out documentation, pre-commissioning forms, and provisional acceptance form. If the Consultant and/or Owner judges that the installation is not complete, or tests are not adequately done by the contractor – the Provisional Acceptance Forms will not be signed back and the contractor shall return to site to complete the work before re-submission. Any charges incurred by the Consultant and or CA for additional visits shall be charged back to the Vendor.

3.11.2.3 If the at the end of the final inspection, the City representative and Consultant deem the project ready for commissioning, they will sign back the Provisional Acceptance Form indicating the project is ready to be commissioned and the job will be considered **Substantially Complete**.

3.11.2.4 The Consultant shall add any noted deficiencies add to the list of previously identified deficiencies within the **Project Close Out Provisional Acceptance Form**

3.11.3 Commissioning

3.11.3.1 A commissioning request shall be made by the contractor after the Real End of Work and shall take place only once the Provisional Acceptance Forms have been signed back by the Owner and Consultant.

3.11.3.2 Refer to Section 3.4 above

3.11.4 Final Acceptance

3.11.4.1 The final acceptance shall follow within forty (40) working days from the start of the warranty.

3.11.5 Reference to the Specifications

3.11.5.1 All inspections, meetings, tests, etc. associated with the work acceptance shall be done by comparing the work with the specifications and the concordance and discordance documents. If there is ambiguity in the specifications or in the concordance and discordance document, the provisions in the specifications and the Consultant's opinion shall prevail. It is the Vendor's responsibility to detect any difference between the specification and the system to be supplied.

3.12 ACCEPTANCE PROCEDURES

3.12.1 General Clauses

3.12.1.1 Notwithstanding the brief definitions of acceptance mentioned in the previous sub-sections, the definitions given in the general clauses are more detailed and these shall prevail in case of any interpretation.

3.12.2 Required Interpretation

3.12.2.1 The Vendor shall supply the Consultant with all the information concerning the identification of points, the functions, the limits, the sequence of operations, the locking devices, the boot-up of the system after a power failure, the readings, the programs, the parameters and all the information associated to the system and the control points.

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3.12.3 Software

3.12.3.1 The Vendor shall download to the central server all software and graphics for the installation and shall activate the system. In addition, he shall be responsible for updating and verifying the database. A computer demonstration, in real time, of the monitoring capacities and commands of the system shall be presented to the Owner before the start-up of the definitive operation of the system. If this demonstration is in conformity with the specifications requirements and Consultant's representative, he shall authorize the start-up of the system.

3.12.4 Start-Up

3.12.4.1 Once the start-up is finalized, the Owner's representative shall inspect and verify the good functioning of the system, the sub-system and its accessories. He shall establish a deficiency list for correction, if necessary.

3.12.5 Repair

3.12.5.1 After receiving the deficiency list, the Vendor shall clear all identified deficiencies and then submit a City of Mississauga **Project Closeout Provisional Acceptance Form** indicating that each component on the deficiency list has been corrected and is functional (refer to Appendix B).

3.12.5.2 When all components detailed in this report have been verified and adjusted to the Owner's satisfaction, a second request for the system acceptance shall be submitted to the Owner. The Owner shall proceed with the provisional acceptance if he finds that the whole is in conformity with the requirements of the specifications.

3.12.5.3 If the Vendor must isolate some system components for verification and/or correction, and for this reason must modify, change, add or remove some hardware, software or accessories to enable the system to function partially out of service, the Vendor shall do the necessary verification for the execution of the changes until the Consultant determines that the system may function normally.

3.12.5.4 All hardware or software defects shall be covered by the warranty and the Vendor shall repair all the deficiencies within reasonable delays (as agreed upon with the Owner when deficiency and/or repair item is first noted). The loggings of the work schedules and deficiency correction reports shall be submitted to the Owner for identifying the defects and repairs being made.

END OF SECTION 25 01 11

EMCS: TRAINING

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EMCS: TRAINING

Part 1 General

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for training program, instructors and training materials, for building Energy Management Control System (EMCS) Work.
- .2 Related Sections.
 - .1 Section 01 33 00 Submittal Procedures.
 - .2 Section 01 78 00 Closeout Submittals.
 - .3 Section 01 79 00 Demonstration and Training
 - .4 Section 25 05 01 EMCS: General Requirements.

1.2 DEFINITIONS

- .1 CDL - Control Description Logic.
- .2 For additional acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements

1.3 SUBMITTALS

- .1 Not Applicable

1.4 TRAINING

- .1 General
 - .1 The supplier shall offer training in the factory and on the site. This training shall be given by the Vendor, during the start-up of the new control system and before the provisional acceptance.
- .2 Quality Assurance
 - .1 Provide a list of the proposed trainer. Trainer must be a competent instructor thoroughly familiar with specific aspects of EMCS installed in facility.
 - .2 Consultant and/or Owner reserves right to approve instructors.
- .3 Instructions
 - .1 Provide instruction to designated personnel in adjustment, operation, maintenance and pertinent safety requirements of EMCS installed.
 - .2 Training to be project-specific.
- .4 Training Documentation
 - .1 Submit training documentation for review 30 days minimum before training. Documentation shall include an agenda for each training day, objectives, a synopsis of each lesson, and instructor's background and project specific qualifications (see 1.4.6).
 - .2 The training documentation can be submitted at the same time as the project's Controls System Operators Manual.

EMCS: TRAINING

.5 Training in the Factory

- .1 Upon request, provide a list of the courses available and the associated costs.

.6 Training on Site (Operator Training)

- .1 TRAINING ON SITE shall be based on instruction for 3 different user groups, with 2 sessions per group and 4 hours of training per session. Each user groups will require a custom user-group specific level of training based on their designated user access level and functional interaction with the EMCS.
- .2 Training to be provided for each EMCS installation (unless otherwise noted in the tender documents).
- .3 Training shall be delivered by a qualified representative of the supplier who was directly involved in the installation of the system for which the operators are being trained.
- .4 Prior to the start of training the Vendor shall ensure the manuals are submitted, approved, and available to hand out to the trainees before the start of the first training session.
- .5 Commissioning and demonstration of the system are an independent task and **shall not** be considered as part of the TRAINING ON SITE.
- .6 Upon completion of the training, each trainee should fully understand the project's DDC system fundamentals. The TRAINING ON SITE shall be given in two (2) parts, but not limited, as follows:

.1 PART ONE: System Overview and Fundamentals

- *Review of As-Built documentation including:*
 - *Overview of systems controlled and related components.*
 - *Overview of project's list of points and objects.*
 - *Overview of project's device network communication architecture.*
 - *Overview or project's specified sequence of control for each system.*
 - *Overview of Alarms Types, Alarm Limits, and Routing.*
 - *Overview Trending Capabilities and Data Storage*

.2 PART TWO: System Access and Operation

- *The second session of training shall be conducted at the Local Operators Workstation Connected to the EMCS in the field via the Enterprise Server. Upon completion of the session, each trainee should fully understand the project's EMCS site specific installed operation.*
- *The training session shall include the following:*
- *A walk-through tour of the mechanical systems and the installed BAS components.*
- *A discussion of the components and functions at each BAS panel.*
- *Logging-in and navigating at operator interface type.*
- *Modifying set-points.*

EMCS: TRAINING

- *Creating, editing, and viewing trends.*
- *Creating, editing, and viewing alarms.*
- *Creating, editing, and viewing operating schedules and events.*
- *Trouble shooting hardware errors.*

1.5 CONTINUOUS TRAINING

- .1 Concerning the training, the dominant role of the Vendor is to supply Consultant with all the information regarding the changes, the modifications, and the upgrading of the system or its components. In particular, the Vendor shall immediately advise Consultant of all the changes in the methods of operation of the system.

1.6 ADDITIONAL TRAINING

- .1 Upon request, list courses offered by name, duration and approximate cost per person per week. Note courses recommended for training supervisory personnel.

1.7 MONITORING OF TRAINING

- .1 Submit preliminary training schedule for review by Owner and consultant. Owner and/or Owner may modify the training schedule and content to conform to site specific requirements.
- .2 Owner may choose to video tape the training session for future use.

Part 2 Products

2.1 NOT USED

Part 3 Execution

3.1 NOT USED

END OF SECTION 25 01 12

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EMCS: GENERAL REQUIREMENTS

Part 1 General

1.1 SUMMARY

1.1.1 Section Includes:

- 1.1.1.1 General requirements and General Profile of the Work for building Energy Monitoring and Control System (EMCS) that are common to Master Specification for Direct Digital Control System Installations City of Mississauga, Ontario.

1.1.2 Related Sections:

- 1.1.2.1 Section 01 33 00 - Submittal Procedures.
- 1.1.2.2 Section 01 77 00 – Closeout Procedures
- 1.1.2.3 Section 01 78 00 – Closeout Submittals
- 1.1.2.4 Section 01 79 00 – Demonstration and Training
- 1.1.2.5 Section 25 01 11 – EMCS: Start-up, Verification and Commissioning
- 1.1.2.6 Section 25 01 12 – EMCS: Training
- 1.1.2.7 Section 25 05 02 - EMCS: Submittals and Review Process.
- 1.1.2.8 Section 25 05 54 - EMCS: Identification.
- 1.1.2.9 Section 25 08 20 – EMCS: Warranty and Maintenance
- 1.1.2.10 Section 25 30 01 – EMCS: Location Area Network
- 1.1.2.11 Section 25 30 02 – EMCS: Building Family of Controllers
- 1.1.2.12 Section 25 30 02 – EMCS: Field Control Devices
- 1.1.2.13 Section 25 90 01 - EMCS: Site Requirements, Applications and System Sequences of Operation.
- 1.1.2.14 Appendix A: City of Mississauga Standards and Guidelines
- 1.1.2.15 Appendix B: City of Mississauga Forms and Templates
- 1.1.2.16 Appendix C: City of Mississauga IT Services Cabling Specifications

1.2 REFERENCES

- 1.2.1 American National Standards Institute (ANSI)/ Institute of Electrical and Electronics Engineers (IEEE).
 - 1.2.1.1 ANSI/ISA 5.5 1985, Graphic Symbols for Process Display
 - 1.2.1.2 ANSI/IEEE 260.1-1993, American National Standard Letter Symbols Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).
- 1.2.2 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
 - 1.2.2.1 ASHRAE STD 135, BACNET - Data Communication Protocol for Building Automation and Control Network.
- 1.2.3 Canadian Standards Association (CSA International).
 - 1.2.3.1 CAN/CSA-Z234.1, Canadian Metric Practice Guide.

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- 1.2.4 Consumer Electronics Association (CEA).
 - 1.2.4.1 CEA-709.1, Control Network Protocol Specification.
- 1.2.5 Department of Justice Canada (Jus).
 - 1.2.5.1 Canadian Environmental Assessment Act (CEAA), 1995, c. 37.
 - 1.2.5.2 Canadian Environmental Protection Act (CEPA), 1999, c. 33.
- 1.2.6 Electrical and Electronic Manufacturers Association (EEMAC).
 - 1.2.6.1 EEMAC 2Y 1, Light Gray Colour for Indoor Switch Gear.
- 1.2.7 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - 1.2.7.1 Material Safety Data Sheets (MSDS).

1.3 DEFINITIONS

1.3.1 ACRONYMS AND ABBREVIATIONS used in EMCS

- AEL - Average Effectiveness Level.
- AIT - Agreement on International Trade.
- AO - Analog Output.
- BAC-net - Building Automation and Control Network.
- CDL - Control Description Logic.
- CoM – City of Mississauga
- CDS - Control Design Schematic.
- COSV - Change of State or Value.
- CPU - Central Processing Unit.
- DI - Digital Input.
- DO - Digital Output.
- DP - Differential Pressure.
- EMCS - Energy Management Control System.
- GUI – Graphical User Interface
- HVAC - Heating, Ventilation, Air Conditioning.
- IDE - Interface Device Equipment.
- I/O - Input/Output.
- ISA - Industry Standard Architecture.
- LAN - Local Area Network.
- LON - Local Operating Network
- NC - Normally Closed.
- NO - Normally Open.
- OEMASC – Original Equipment Manufacturer Application Specific Controllers
- OWS – Operator’s Workstation.
- PCMCIA - Personal Computer Micro-Card Interface Adapter.

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- PID - Proportional, Integral and Derivative.
 - RAM - Random Access Memory.
 - RPDC – Remote Programable Digital Controllers
 - SRPDC – Supervisory Remote Programable Digital Controllers
 - SP - Static Pressure.
 - ROM - Read Only Memory.
 - TEC - Terminal Equipment Controller.
 - USB - Universal Serial Bus.
 - UPS - Uninterruptible Power Supply.
 - VAV - Variable Air Volume.
- 1.3.2 Point: may be logical or physical.
- 1.3.2.1 Logical points: values calculated by system such as set points, totals, counts, derived corrections and may include, but not limited to result of and statements in CDL's.
 - 1.3.2.2 Physical points: inputs or outputs which have hardware wired to controllers which are measuring physical properties or providing status conditions of contacts or relays which provide interaction with related equipment (stop, start) and valve or damper actuators.
- 1.3.3 Point Name: All points shall be named in accordance with the **City of Mississauga, Point Naming Convention** – Refer to Appendix A and Section 25 05 54 EMCS: Identification

1.4 SUBMITTALS

- 1.4.1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures and 25 05 02 - EMCS: Submittals and Review Process.

1.5 DESIGN REQUIREMENT

- 1.5.1 This document should be read in conjunction with the design and specification of any New and/or Replacement Energy Management Control System (EMCS), and EMCS upgrade projects designed for the City of Mississauga, Ontario. Because these Master specifications are periodically updated, the current and most recent version of this document should be obtained directly from the City of Mississauga, Ontario Project Manager for each project.
- 1.5.2 The basis of design for all EMCS Upgrades incorporates the following system architecture:
- 1.5.2.1 A dedicated EMCS Enterprise server (complete with operating system, software tools, licenses, etc.) and Tridium Niagara 4 EMCS Enterprise Server Software (ESS) package that has a fully open and accessible licensing structure.
 - 1.5.2.2 The EMCS Server and Tridium Niagara 4 ESS is already in place. It shall be the responsibility of the contractor to communicate with CoM Facilities Department to determine the current reversion Niagara 4 Supervisor

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- operating and required revision of JACE to be used at the start of each project.
- 1.5.2.3 Databases shall be Microsoft SQL-based in accordance with the City of Mississauga ITS standard.
- 1.5.2.4 Secondary back-up server(s) with database software as required for all storage of all system database parameters including; back-up of all field panel programming, trend data, and site-specific color graphics
- 1.5.2.5 Both servers are existing and reside in a CoM designated server room, connected to the CoM local area network (LAN) and wide area network (“WAN”) for communication to multiple sites and multiple pre-qualified EMCS products.
- 1.5.2.6 EMCS upgrades and installation for each facility shall comprise the supply and installation of a new supervisory remote digital controller (“SRPDC”) connected to remote programmable digital controllers (“RPDC”), terminal equipment controllers (“TEC”) and original equipment manufacturer application specific controllers (“OEMASC”) over a EMCS vendor supplied BACNet communication network(s).
- 1.5.2.7 The EMCS vendor supplied SRPDC shall be a Tridium Niagara JACE 8000 Series controller(s) of sufficient number and capacity to manage the number of field controllers and points as specified for the specific installation.
- 1.5.2.8 All JACE panels shall come with Open NiCS statements and shall be installed with the most recent version of Niagara 4 at the time of purchase (ie – v4.8). EMCS Vendor shall confirm the version with CoM before ordering.
- 1.5.2.9 The SRPDC shall communicate to the EMCS server over the COM WAN using TCP/IP communications protocol. Only one (1) network drop and IP address shall be provided by COM at a given site. EMCS and SRPDC solutions must support LAN-, WAN-, and cellular-connected facility installations based on network availability that will be specified for each location.
- 1.5.2.10 The EMCS Vendor shall be responsible to supply and install all necessary routers, switches, cabling, conduits and enclosures to create any necessary sub-networks for extension of TCP/IP Communication network to accommodate multiple SRPDC on one site (or IP based controllers where approved by City of Mississauga). Ethernet communication cabling for EMCS sub-networks shall be in EMT conduit (both exposed and concealed). Refer to Appendix C for City of Mississauga cabling specifications and requirements.
- 1.5.2.11 All SRPDC, RPDC, TEC, switches, routers, etc. to be in lockable NEMA rated enclosures (except where otherwise – i.e. VAV Box TEC may be mounted directly on the VAV Box). If in doubt, seek clarification from COM before submitting a quotation on any project.
- 1.5.2.12 The system architecture requires that the SRPDC be set-up and programmed to manage and monitor communication between all field level controllers (RPDC, TEC, OEMASC), and communicate all EMCS

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activity to the ESS over the City's Ethernet based WAN using TCP/IP communication protocol. All EMCS field controllers shall be capable of standalone operation on loss of communication with the SRPDC. **No physical control points shall reside on the SRPDC.**

- 1.5.2.13 All graphics, EMCS programming, trend data, security settings, access level priorities, etc. shall be uploaded by the EMCS vendor(s) and stored on the Server for each project (without need for the involvement of others). This shall be repeated at the start of commissioning and again upon completion of deficiency clean-up and as-built. Remote access will be provided in accordance with current City of Mississauga ITS policies, procedures and processes.
- 1.5.3 Coordinate with Original Equipment Manufacturer (OEM) regarding dedicated application specific controllers as supplied by Others (OEMASC).
- 1.5.3.1 The use of dedicated equipment controls supplied by others shall be pre-approved by the City of Mississauga, Ontario Facilities Management prior to design and specification.
- 1.5.3.2 These shall include but not be limited to the following:
- Chillers,
 - Heat pumps,
 - Gas fired furnaces,
 - Boilers
 - VFD's
 - Rooftop Units
 - VRF's
 - Refrigeration Systems
 - Generators
 - Utility Meters/Sub Meters
 - Lighting Controls
 - Other equipment that come with OEM Installed On-board micro-processor controls.
- 1.5.3.3 All equipment of this nature shall come with a BACNet compliant communications interface communicating via BACNet IP or MS/TP (as indicated in the specified project specific system architecture) or approved equivalent communication protocol that is supported by the Pre-Qualified BAS Vendor Hardware interface modules – i.e. LON/Modbus/etc.). **The use of Non-BACNet communication protocols must be PREAPPROVED by CoM and shall only be considered if Bac-Net is not available.**
- 1.5.3.4 Design consultant shall fully identify and indicate the relationship between the EMCS and the dedicated controls for specific HVAC equipment as supplied by others, spelling out the points to be monitored, points to be modified, how and where to display on the graphics, responsibility of

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- HVAC equipment representative and EMCS vendor for programming, graphics and interface, etc.
- 1.5.3.5 Connection to the OEM supplied controls shall be via a dedicated Sub-Net communication BUS running from the Supervisory Remote Programmable Digital Controller (SRPDC) to the OEMASC's. The SRPDC should communicate to OEMASC using BAC-net (IP) communication protocol. Please refer to the City of Mississauga System Architecture Diagram
- 1.5.3.6 The OEMASC as mentioned in Section 253001-EMCS: Building Controllers, are to be stand-alone microprocessor-based controllers that handle the staging, sequencing, control and coordination of specific HVAC equipment and related systems components (Example Chillers/Boilers AHU's/ Other). This provides a sole source of responsibility for the equipment's performance to avoid damage to the equipment, to increase safety, and to increase vendor and manufacturer responsiveness during problem solving.
- 1.5.3.7 OEMASC shall be a fully BAC-net compliant device to facilitate interoperability between OEM electrical/mechanical sub-systems and BAC-net EMCS or provide the necessary gateway to integrate into the web-based BAC-net EMCS using the BAC-net communication protocol.
- 1.5.3.8 The OEM shall provide any software or hardware required to access or modify any electrical/mechanical subsystems *i.e. RTUs, VSD's, Chillers, Lighting controls and /or Electrical Monitoring & metering.
- 1.5.3.9 Typical gateway requirements for projects include but not be limited: A BAC-net interface to the chillers' manufacturers, a BAC-net interface to the VSD manufacturers' product(s), a BAC-net interface to the electrical monitoring manufacturers product(s).
- 1.5.3.10 A Modbus interface may be used only when a BAC-net interface is not available from the equipment OEM. If the equipment manufacturer does not have this capability, they shall contact the authorized representative of Construction Specification of Canada (CSC) for assistance and shall include in their equipment price any necessary hardware and/or software obtained from the CSC to comply with this section. Cost alone is not an acceptable reason for not providing a BAC-net interface.
- 1.5.3.11 OEM Configuration Tools and licences required to configure all OEMASC installed on this project, shall be provided by the equipment EMCS Vendor.
- 1.5.3.12 All submittals for both EMCS and OEM supplied equipment shall identify the interface between EMCS and OEM supplied controller including available points to read/write between systems.
- 1.5.3.13 Set up, testing and commissioning of the interface between OEMASC and the EMCS control system shall be carried out with both parties (OEM Programmer and EMCS Programmer) present on site to ensure the proper communication set up and establishing control priority levels and parameters. The cost of these services shall be included in the price from both vendors.

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- 1.5.3.14 Specifying Consultant shall ensure to include for provision of any necessary OEM Configuration Tools and Licenses as required to connect and setup the OEM controllers and the interface to base EMCS system.
- 1.5.4 Fire and Emergency Power
 - 1.5.4.1 Only the Dedicated Fire Alarm system should control life safety equipment such as smoke evacuation and make-up air fans serving; atriums, elevator shafts, stairwells, etc. Likewise, only the Dedicated Fire Alarm system should control the smoke control dampers and related systems.
 - 1.5.4.2 Fire and smoke damper position may be monitored by the EMCS but shall not be used for the purposes of control. The Dedicated Fire Alarm system alone should provide the functional control of these dampers and necessary fan commands during alarm conditions.
 - 1.5.4.3 The Dedicated Fire Alarm system should directly shut down all air handling units as required by Code through a hardwired signal. That shut down authority should be effective for all positions of the local Hand-Off-Auto (H-O-A) selector switch and/or variable speed drive (VSD) controls.
 - 1.5.4.4 The EMCS system shall not control air handling units after activation of shutdown sequence by the fire alarm panel. The EMCS shall resume control only after confirmed reset of the fire alarm system.
 - 1.5.4.5 The EMCS system shall monitor the Dedicated Fire Alarm panel to determine when the building is under a fire alarm condition. In cases where the EMCS system is interfaced to the Alarm Panel through a direct communications interface (i.e. BACNet), the EMCS functions shall be distinct and separate from the Fire Alarm.
 - 1.5.4.6 Smoke/fire dampers and smoke/fire damper actuators are to be specified under the air distribution system, not under Master EMCS specifications.
 - 1.5.4.7 In buildings where mechanical systems operate under EMCS control during emergency power conditions, the EMCS system shall monitor the appropriate emergency power transfer switch to determine when there is loss of normal power and also the restoration of normal power.
 - 1.5.4.8 The EMCS shall follow specified sequences for Emergency Power Operation during a power failure including but not limited to the restart of equipment based on specified equipment start-up priority.
- 1.5.5 Use of Colour Graphics & Graphical User Interface
 - 1.5.5.1 The use of dynamic colour graphics to their maximum extent, are required to improve the presentation and the interpretation of data.
 - 1.5.5.2 The Graphic displays shall have full-screen resolution when viewed on user interfaces (i.e. laptop or PC) through the Owner's Enterprise server. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh".
 - 1.5.5.3 The Graphical User Interface shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing, of, and access to, the hierarchical structure of the database. In addition, menu pull-downs, and toolbars shall employ

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- buttons, commands and navigation to permit the operator to perform tasks with minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line that displays the location and the selected object identification.
- 1.5.5.4 The contractor shall provide all software necessary to permit the owner's designate super user to create, modify, delete, file and recall all graphics. The software package shall encompass graphical presentation of the geographical territory of the site, floor plans and equipment locations, c/w all graphics required, and sufficient expansion for the ultimate system.
- 1.5.5.5 The system shall be capable of generating any graphic in conjunction with any alarm of change-of-state reported.
- 1.5.5.6 Command software shall be provided to:
- Create a new graphic picture
 - Modify a portion of a graphic picture
 - Delete a graphic picture
 - Call up and cancel the display of a graphic picture
- 1.5.5.7 The graphic package shall contain a library of HVAC related standard graphics and graphic symbols.
- 1.5.5.8 In the development of a graphic picture, the graphic software shall support all operator actions necessary to:
- Define the background
 - Establish colours
 - Define and locate symbols
 - Position and edit alpha-numeric descriptors of any height
 - Establish sources of real-time data and the location of their readouts
- 1.5.5.9 The graphics operating values and data, such as set-points, process values, alarms and parameters should be dynamically updated.
- 1.5.5.10 Creation of graphics must be possible using a mouse or equivalent screen point's device.
- 1.5.5.11 The package should be equipped with point trend graphical presentation of historical logged data, time schedule editor and alarms. The operator should read alarms from the graphics and acknowledge.
- 1.5.5.12 Vendors shall provide new graphics and programming both on site and in a vendor specific dedicated server (customer supplied) Located on the City Control and monitoring Centre.
- 1.5.5.13 The graphics generated for each site and project shall be consistent in nature from building to building, and system to system, etc. All Graphics shall conform to the ***City of Mississauga Graphical User Interface Standard***. The Standard is to under development by the City, Consultant, and the successful bidder of an initial pilot project that will include an implemented live **Template Workstation**.

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- 1.5.5.14 Access to the template workstation shall be granted to all vendors at the start of each new project for purposes of determining the basis and layout of COM system graphics, along with specific objectives/instruction on graphical needs of the project from COM. EMCS vendor shall use the Template Station graphics as starting point to create NEW customized, site specific project graphics. The new graphics are to match the outlined template look, layout, and colour scheme while displaying the building and system specific information for that site and the direction of COM.
- 1.5.5.15 Graphics shall be submitted for review and approval by COM before acceptance and their application on site. Contractor shall make all necessary changes to satisfy the City and should anticipate a reiterative process with multiple submissions before the Graphics are finalized. **NO WORK ON SITE SHALL BEGIN** until the graphics have been submitted, reviewed and approved.
- 1.5.5.16 Graphical Interface shall be programmed to have multiple levels of user access (as defined with City of Mississauga Facilities Planning) via Active Directory. EMCS Vendor shall work with City of Mississauga ITS to establish levels of access and appropriate user groups.
- 1.5.5.17 The Graphical Interface shall include a minimum of the following features/pages:
- Main Access Page: Shall display a picture of the building exterior and shall be the entry point into the system with pop-up requesting username and password. Once access is granted and user level is defined, the graphic shall populate with site related information and links to floor plans, etc.
 - Floor Plans (Minimum 1 per floor): Shall display available space temperatures, controller locations, areas served by each system (i.e. (HVAC) systems, RTU1, RTU2, etc.). There shall be graphical interface buttons for each system/area to provide timed overrides and event mode buttons for all areas served. This graphic will be accessible by all levels of users and shall have links to the individual system graphics for all equipment. The areas served by each piece of equipment shall be colour coded in a convention as identified in the ***City of Mississauga Graphical Standard*** (refer to Appendix A)
 - System Graphics: (Minimum 1 per system) – Shall be accessed through floor plans and the main menu page. Shall display all set points, damper commands/positions, valve commands/positions, calculated set points, etc. This page shall be viewable by all users. Low level user shall only be able to view information, mid-level access shall have capability for temporary override of all command points for valves, dampers etc. Hi level access shall be able to override all points, set points, schedules, etc. All overrides shall be monitored, alarmed and tracked in reports accessed by the super user. Links from this graphic shall be provided to show description of sequence of operation and PDF files showing hardware diagrams

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with “as-built” points data indicating what points are terminated to the panel, source of power, controller model, etc.

- Settings page (1 per system) – this page would include all access to Schedules, set points, reset values, alarm settings, time delays, deadbands, etc. – essentially all points identified as “Adjustable” in the sequence of operations.
- All points shall be named according to new naming convention to be supplied by City of Mississauga and detailed in **Appendix A** Naming convention to include numeric building identification, alpha numeric system identification and alpha numeric point descriptor.
- Terminal Equipment Controllers (TEC) Quick Reference Pages – in addition to accessing individual terminal equipment through thermostat and controller links on each floor plan Graphic, the Vendor shall provide a link to Terminal Equipment Controller (TEC) Quick Reference Pages via Navigation Bar(s) in the System Menu. The Quick Reference Page will provide a Tabular summary of data for multiple Terminal Equipment Controllers including but not limited to; VAV Boxes, Unit Ventilators, Induction Terminals, Convactor/Radiation Terminals, Heat Pumps, Fan Coils, etc.
- These tables shall summarize all TEC in a given area offering a quick view of the state of all units on each particular floor area providing information on; the status of unit operation, temperatures, set-points, and commands modes, i.e. occupied/unoccupied, overrides and dampers, valves control statuses.
- The operator with proper access level shall be able to utilize the links in these tables to control and command set-point changes and trouble shoot the systems.

1.5.6 Equipment Standardization

- 1.5.6.1 Whenever possible, the system shall use standard and readily available components and installation techniques to minimize the risks that may arise for “specialized” equipment and devices. Proven materials, software, techniques, etc. are preferred.

1.5.7 Training

- 1.5.7.1 The EMCS Vendor shall be responsible to provide training. (Refer to Section 25 01 12 EMCS Training).

1.5.8 Communications

- 1.5.8.1 The Communication Network from the SRPDC to the Server shall utilize the Owner’s existing ETHERNET TCP/IP network protocol. Communication between SRPDC and RPDC panels and field controllers and devices shall be via BAC-net Communication Network in accordance with **ANSI/ASHRAE 135 2004**. The Contactor shall provide a peer-to-peer networked, fully distributed control system for the buildings electrical and mechanical systems.

1.5.9 Reliability/Security

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- 1.5.9.1 The system shall include protective measures in order to minimize the interruption risks and non-authorized operation of the system. These measures include but not limited to the following:
- Equipment/device address duplication
 - Protection against atmospheric conditions
 - High power electrical protection
 - Distributed intelligence
 - Analogue and digital control
 - Limited access to the system
 - Proven software
 - Spare parts
 - Remote software down and up loading
 - Maintained Memory and Programming on power failure
 - Physical spacing between components
 - Locking panels
 - “Fail safe” programming
 - Protection from radio wave interference (ex: use of walkie-talkies near the DDC.)
 - TLS Encryption and Security Certificates
- 1.5.9.2 Provide and maintain independent validation by a reputable application security assessor of implementation of OWASP ASVS v3.0.x Level 2 application security controls. Any exceptions to Level 2 controls, or acceptance of an alternative control framework (and exceptions thereto), must be managed and approved through standard City of Mississauga Information Technology Services (information security risk management) and Records Management (privacy management) processes.
- 1.5.9.3 Ensure that re-validation is performed on an annual basis at a minimum, or upon any significant changes to website/application functionality
- 1.5.10 Back-up Databases
- 1.5.10.1 Back-up copies of all SRPDC,RPDC & TEC system controller databases shall be stored in the Owner’s dedicated EMCS Server. In addition, the vendor shall store a copy of all back-up programming for each controller and site and shall furnish to the owner upon request at no additional charge.
- 1.5.10.2 Continuous supervision of the integrity of all SRPDC,RPDC & TEC system controller databases shall be provided. In the event that any SRPDC,RPDC & TEC system controller on the network experiences a loss of its database for any reason, the system shall automatically download a new copy of the respective database to restore proper operation.
- 1.5.10.3 Database back-up/download shall occur over the local area network without operator intervention and again over the COM WAN at a

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frequency set-up by the installing contractor in coordination with CoM Facilities department. Users shall also have the ability to manually execute downloads of any or all portions of a SRPDC, RPDC & TEC system controller database.

1.6 OBJECTIVES

1.6.1 General Objectives

- 1.6.1.1 The Controls Contractor shall supply and install a complete new BAC-net based (DDC) direct digital control Energy Management Control System (EMCS) system as required to achieve the Sequences of control for HVAC systems, heating & cooling plants, etc. and/or to replace the existing control systems used by the Owner.
- 1.6.1.2 No Gateways, communication bridges, protocol Translators or any other electronic devices that translate other communication protocols to the BAC-net communication protocol shall be permitted for the EMCS installation. Gateways may only be used as required for interfacing to major HVAC equipment and other building systems as specified elsewhere (i.e. – Chillers, Boilers, Power Meters, lighting, etc.)
- 1.6.1.3 The new EMCS control system shall consist of a high-speed Ethernet, peer-to-peer (through a BAC-net) network using TCP/IP protocol and DDC controllers interfacing with the Owner's dedicated EMCS enterprise server through the **SPRDC**. The EMCS server shall allow facility operators and other City of Mississauga Staff to interface with the control network via dynamic color graphics.
- 1.6.1.4 The new EMCS shall be provided with a complete Web enabled graphical user interface (GUI). The Web enabled GUI shall operate on industry standard PC hardware. The new EMCS system graphics shall be HTML 5 based vector scalable graphics and must be able to be viewed from any computer or hand held device (i.e. smart phone, tablet, etc.) on the owner supplied network or any computer on the internet (via a VPN) using no special software other than browsers (Microsoft internet explorer, Safari, or equivalent). Any black boxes or proprietary server hardware will not be acceptable.
- 1.6.1.5 The new EMCS shall be flexible in nature and shall permit expansion of both capacity and functionality through the addition of EMCS controllers, sensors, actuators and operator devices.
- 1.6.1.6 The new system Architecture design shall eliminate dependence upon any single device for alarm, event reporting and control functionality. Each EMCS controller shall operate independently by performing its own specified control programs and routines, operator I/O, Alarm management, data collection and sequences of operations. The failure of any single device, component or network connection shall not interrupt the execution of any control strategy, routines, reporting, or any operator interface device. Refer to Appendix A for System Architecture Diagram.
- 1.6.1.7 The EMCS Controllers shall be able to access data from, or send control commands and alarm reports directly to, any other controller or

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combination of controllers on the local area network without dependence upon a central processing device. EMCS controllers shall also be able to send alarm reports to unlimited email devices such as cell phones, pagers, or standard alarm terminals via Supervisory Remote Digital Controller (SRPDC) and the Owner's EMCS Server using remote alarm software.

- 1.6.1.8 All products used in the project installation shall be new and currently under manufacturer warranty and shall have been applied in similar installations of a minimum of two years. Spare parts shall be available for at least five years after completion of this contract. Security certifications must be maintained throughout the expected life of any/all components
- 1.6.1.9 All controllers supplied for control of HVAC equipment shall be of One Manufacturer throughout.
- 1.6.1.10 For replacement of existing systems, contractor to remove existing direct digital control panel(s) and ***return to Owner upon request or dispose of if not required by owner***. Existing sensors (pneumatic/digital/electronic) made redundant or unnecessary by this work shall be removed.
- 1.6.1.11 Unless otherwise noted, all existing pneumatically operated control valves shall be replaced with new electronically actuated control valves. Where indicated to remain, pneumatically actuated devices shall be interfaced with new electro-pneumatic transducers. Contractor shall run new main air pneumatic tubing from the air compressor system to transducers and again to devices.
- 1.6.1.12 Where noted on drawings and/or points list, existing control valves shall be replaced with new electronic control valves operating on a 0-10Vdc or 4-20 mA signal. Contractor shall be responsible for complete supply and installation (mechanical/electrical/controls) of valves and actuators.
- 1.6.1.13 Remove all existing pneumatic damper actuators. Supply and install replacement electronic actuators operating on a 0-10Vdc or 4-20mA signal

1.6.2 Global Scope

- 1.6.2.1 The City of Mississauga owns, operates, and maintains facilities across the greater area and is comprised of several buildings of different size and use (Museum, libraries, Administrative, Community Center, Fire Halls Nursing Home etc.). The City is in the process of upgrading and standardizing the controls to achieve energy efficiency goals and improved thermal comfort. As part of the process the City will be tendering a number of requests to solicit stipulated price contract Bids for the installation of the New EMCS including connection of these installations to the City's Host EMCS Enterprise Server
- 1.6.2.2 The scope of work shall include remote programmable BACNet Certified Supervisory Remote Digital Controllers (SRPDC) and associated controllers c/w control and sensor devices, installed in each building and connected to a host server in another building on campus.
- 1.6.2.3 City of Mississauga Pre-Qualified EMCS Vendors and Products are:

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Company Name	Branch Location	Contact Person	EMCS Family of Products
Facio Corporation	145 West Beaver Creek Rd, Richmond Hill, ON L4B 1C6	Gary MacMillan gmacmillan@facio.ca	Honeywell Spyder BacNet IP series (programmable via Niagara Workbench) and Ciper series controller. Distech Eclipse BacNet IP series controllers
Automated Controls and Energy Solutions Group Inc.	5285 Solar Dr Unit 103, Mississauga, ON L4W 5B8	Murat Kinaci estimates@acesolutionsgroup.ca	Honeywell Spyder BacNet IP series (programmable via Niagara Workbench) and Ciper series controller
Airon HVAC and Control Ltd.	5150 Fairview St, Burlington, ON L7L 6B7	Tanya Meade <i>tanyam@airongroup.ca</i>	Honeywell Spyder BacNet IP series (programmable via Niagara Workbench) and Ciper series controller
Ainsworth Inc.	131 Bermondsey Rd, North York, ON M4A 1X4	Julian Rogochevsky <i>Julian.Rogochevsky@ainsworth.com</i>	Schneider Smart X BacNet IP series, with Niagara module (programmable via Niagara Workbench)
Accu-Temp Systems Inc.	226 St Leger St, Kitchener, ON N2H 4M5	Scott Ward <i>Scottw@accutempsystems.com</i>	Honeywell Spyder BacNet IP series (programmable via Niagara Workbench) and

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			Ciper series controller
Modern Niagara Toronto Inc	8125 Hwy 50 Vaughan, Ontario L4L 1A5	Sam Boyajian <i>Sboyajian@modernniagara.com</i>	Distech – Eclypse – Bacnet IP series controllers

1.6.3 Owner's Needs and Rights

- 1.6.3.1 The Owner demands equipment using Direct Digital Control (DDC) and distributed intelligence that is proven and shall be currently under manufacturer warranty. The operator interfaces, Building Controllers, System Controllers, and Application Specific Controllers shall be connected directly through a BAC-net communication internetwork. It is essential that all proposed systems strictly meet the Owner's needs.
- 1.6.3.2 The Owner has a full ownership of all products including hardware, software, graphic files, dominations, etc.

1.6.4 General Prescriptions and Concerns

- 1.6.4.1 Conform to all general sections of these specifications (General Conditions, General Requirements, etc.) The present section is an integral part of the Pre-Approved Direct Digital Control Vendor's scope of work and deliverables under contract with the Owner, as well as the specific scope of work for detailed for individual installations within each facility.

1.6.5 Description of Work

- 1.6.5.1 Supply, install and render operational an Energy Management Control system, including communications interfaces, to the Owner's proprietary communication network. The connections to the proprietary communications network shall be provided by the Owner. ***Contractor shall be responsible for communicating and coordinating IP drop locations with Owner's designated IT representative)***
- 1.6.5.2 The new EMCS system shall incorporate a **Supervisory Remote Programmable Digital Controller** (SRPDC). The SRPDC to is be located in the owner's designate main mechanical room or other owner designated location, complete with necessary interface hardware/software to allow communication over the City of Mississauga intranet using TCP/IP BAC-net standard protocol. **A UPS shall be provided by the EMCS Vendor** for the SRPDC to condition power and provide 20 minutes of uninterrupted power to avoid loss of communication during temporary power outage.
- 1.6.5.3 The SRPDC shall communicate to third party OEM controllers through separate vendor supplied dedicated Sub-Network. Sub-Network shall also be BAC-net based Local Area Network (LAN).
- 1.6.5.4 The City of Mississauga intends to install Wi-Fi communications throughout each of its facilities including coverage in mechanical rooms. Vendor shall set up HTML 5 scalable graphics that can be viewed and operated via mobile devices (i.e. Smart Phone and/or tablets) accessible through the Public or Owner's Wi-Fi network. The purpose of these

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graphics is to facilitate the service and maintenance of the systems by the Owner's technicians. Access to the Graphics via this method shall be through the EMCS Enterprise Server Software. Also, at each site the graphics shall reside on the SRPDC and shall be accessible by a laptop or operator's workstation. Security Access Levels as outlined in these specifications shall be consistent and maintained when accessing controls through any or all PC/Laptop/Handheld Devices.

- 1.6.5.5 The installation of all the necessary equipment, complete with programming, should be in accordance with the control plans, system sequences of operation, the specific scope of work for each building and any other information in these and/or other specifications associated with the specific project. The specific scope of work is an integral part of these and other specifications, where other specifications are in contradiction to these specifications it is the contractor's responsibility to bring it to the attention of the Owner prior to submitting a bid.
- 1.6.5.6 The contractor shall install an adequate quantity of controls in order to respond to the requirements of each facility.
- 1.6.5.7 Furnish and install all necessary elements in order to execute the described sequences of operations.
- 1.6.5.8 The Control contractor shall be responsible for having the required electrical work executed by a qualified electrician and include the associated costs in his tender.
- 1.6.5.9 All electrical installation shall be made in conformity with the Electrician Safety Authority (ESA) and according to the applicable codes and regulations in force.
- 1.6.5.10 Provide all necessary power supplies from dedicated circuits in new/existing power panels.
- 1.6.5.11 Provide all the necessary wiring for the remote start/stop of equipment.
- 1.6.5.12 Install all conduits for power, control, and communication wiring in accordance with these specifications
- 1.6.5.13 Install a BACNet based communication bus between SRPDC, RPDC and the field communication devices of the building.

Part 2 Products

2.1 EQUIPMENT

- 2.1.1 Control Network Protocol and Data Communication Protocol: to ASHRAE STD 135.
- 2.1.2 Complete list of equipment and materials to be used on project and forming part of tender documents by adding manufacturer's name, model number and details of materials, and submit for approval.

Part 3 Execution

3.1 INSTALLATION

- 3.1.1 The EMCS Vendor shall furnish and install all apparatus, accessories, wires and instrumentation piping necessary to the completion and good functioning of the system.

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- 3.1.2 The system shall be installed by electricians, technicians and mechanics trained and qualified for this type of work.
- 3.1.3 The supervision and start-up of the automation system shall be done on the dates stipulated by the Owner.
- 3.1.4 The system shall be installed in accordance with these specifications.
- 3.1.5 Electrical Wiring
 - Submit shop drawings and product data in accordance with the requirements as detailed in these specifications.
 - All wiring shall comply with local and national electrical codes and the requirements of Division 16.
 - All control and sensor wiring shall be colour coded in compliance with Section 25 05 54.
 - All wiring shall be plenum rated Beldon or equivalent, #18, #20 or #22-gauge, non-shielded wiring when in conduit, shielded where exposed. Lengths for specific gauge and applications shall comply with the controls' manufacturer's guidelines. Exposed low voltage wiring shall be in EMT conduit, plenum rated cable above ceilings (neatly secured with Tie-Wraps to building elements), and wire mould in finished areas where noted. All power wiring (120V) shall be in EMT conduit. The final 18" of wiring into mechanical equipment shall be in liquid tight, mounted to ensure vibration is not transmitted from equipment to conduit.
 - Size 24 VAC wiring according to length refer to manufacturer's voltage drop table and size wire to achieve a minimum of 22 VAC at the control being powered.
 - The use of wire-nuts for connections on communication bus is prohibited. Use "Scotlok" 3M terminals or other similar terminal block type product.
 - All new controls shall have an independent power supply with dedicated breaker. The contractor shall be responsible for finding available power and labelling panel(s) for new control circuits.
 - All controllers and field devices shall be identified in accordance with Section 25 05 54

3.2 NEW SYSTEMS

- 3.2.1 Supply and install a BAC-net based Supervisory remote programmable digital control panel (SRPDC) in the designated main Mechanical room or other location as indicated on the drawings or designated by the Owner.
- 3.2.2 The SRPDC shall be powered by a dedicated circuit from the nearest power panel and conditioned through a UPS before powering the panel. This UPS will also serve to back-up power for the SRPDC so that it may maintain communication with the Owner's designated Enterprise Server during power failure at individual buildings and ensure systematic re-start of equipment upon restoration of commercial power (through Restart Programming).

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- 3.2.3 Install all necessary equipment (sensors, wiring, relays, etc.) and complete programming of the installation (alarm messages, graphics, communications, application programs, etc.) in accordance with the sequences of operations and the control plans as specified.
- 3.2.4 The running status of equipment such as fans, pumps, compressors, etc. shall be detected by a current sensing relay. These relays shall be calibrated consequently on site. Auxiliary contacts or airflow switches are not accepted as a proof of run unless specified elsewhere.
- 3.2.5 The power supply (120V) to the control devices, which controls the mechanical systems should be from a dedicated power circuit and connected to the nearest electrical panel with the circuit identified at the power panel, on the drawings and at the control device.
- 3.2.6 The control equipment locations shown on the plans is approximate only and final locations shall be coordinated with the Owner and/or Consultant during the work execution. The plans are not to scale, and they indicate approximate location only.
- 3.2.7 All the new wiring and piping of the new control system shall be the contractor's responsibility, including the power and control wiring, electrical conduit, control devices, etc. Communication wiring between the SRPDC and the Owner's Ethernet Switch shall be done by others but coordinated by this contractor.
- 3.2.8 The Contractor shall coordinate the test of the fire alarm system with the Owner's fire alarm company to verify that the interlocks with the ventilation system have been properly maintained and are functional.
- 3.2.9 The Contractor shall coordinate a power failure test run done with the Owner in order to verify the SRPDC reactions to this test. This test shall take place after the switchover and start-up of the SRPDC, RPDC and TEC controllers.
- 3.2.10 The Contractor shall acquire, at his own expense, all information on manufacturer's equipment such as: boilers, rooftop HVAC systems, chillers, fire panels, VSD's etc. in order to identify the necessary electric wiring required for the proper functioning of the new system. Any relays and/or interface modules for the control panel shall be supplied by the Contractor at his own expense.
- 3.2.11 All controllers including but not limited to SRPD, RPDC, TEC and OEMASC shall comply with all aforementioned EMCS system requirements and shall comply with the BACNet Protocol in accordance with the latest version of **ANSI/ASHRAE Standard 135.-2004.** All controllers (other than OEMASC) shall be of one manufacturer.
- 3.2.12 Remote Programmable Digital Controllers (RPDC) shall be furnished by the EMCS vendor as necessary to control large point count of major mechanical equipment, and the implementation of EMCS global control strategies.
- 3.2.13 Every mechanical system and/or large piece of mechanical equipment (i.e., Heating Plant, Chiller Water Plant, Large AHU, etc.) shall have one (1) dedicated RPDC with sufficient point capacity and memory such that it shall be connected to ALL field devices and terminal components (devices & sensors) associated with that system and/or piece of equipment. Distributed control of one (1) single piece of large equipment shall not be performed by multiple controllers.

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3.2.14 The SRPDC shall be microprocessor based and shall execute many functions completely without the help of the central system. For example, they shall:

- Interrogate inputs and outputs
- Calculate by using real time data and other parameters
- Execute the Enterprise Server Software instructions
- Report information to the Enterprise Server Software
- Facilitate communicate between other field controllers (RPDC, TEC, and OEMASC) allowing interrogation and operation modification without the need to connect to the Server.

3.2.15 Function of the New System

3.2.15.1 Collection of Data Base

- The system shall collect different data from the mechanical and electrical systems of the automated buildings.

3.2.15.2 Control Capacity

- The system shall permit the automatic and manual control of the data and the equipment.

3.2.15.3 Programmability

- The system shall be fully programmable in order to perform basic operations automatically and certain calculations frequently used (i.e. reset schedules and calculated system set points, etc.).

3.2.15.4 Report Printing and Generation

- The system shall produce certain reports and/or graphics as detailed in these specifications through the use of external devices such as a printer.

3.2.15.5 Database Management

- It shall be possible for the operator to view and/or print out any portion of the database including, as a minimum:
 - Point configuration
 - Alarm limits
 - Schedules (Note: The system shall permit different schedules: weekly, Holiday, Alternate schedule and Temporary schedule for special events and work orders)
 - Report configuration
 - Graphic configuration
 - Global program configuration
 - SRPDC & DDC software

3.3 REPLACEMENT OF EXISTING SYSTEMS:

3.3.1 Where the specified EMCS is intended for the replacement of existing control systems, remove **all components** of the existing control system which are not required including but not limited to:

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- 3.3.1.1 Electric and/or pneumatic controllers
- 3.3.1.2 Instrumentation supports and instrument panels
- 3.3.1.3 Existing control panel enclosures
- 3.3.1.4 Pneumatic Thermostats and all pneumatic tubing (in their entirety)
- 3.3.1.5 All existing control transformers, relays, wiring, timers, conduits, switches, thermostats, humidistats, control piping, etc. made redundant as a result of this scope of work. Where existing control and/or power wiring is unmarked and un-know, vendor shall trace and remove.
- 3.3.2 It is preferable that all new control panel(s) be installed where existing control panels have been removed or in close proximity.
- 3.3.3 If the contractor wished to re-use any existing control components (conduit, wires, cabinets) this shall be clearly communicated to the owner and submitted for approval prior to closing. It shall also be clearly identified in the bid submission as an Optional Price Deduction and the contractor shall warranty any re-used control components for a period of one (1) year from date of final acceptance
- 3.3.4 It is preferable that all new control panel(s) be installed where existing control panel have been removed.
- 3.3.5 Where approval is given for equipment is to be re-used, contractor shall carry out all necessary tests to ensure that the equipment will perform satisfactorily in its final duty as specified. All Testing shall be carried out prior to re-use. If after testing any items cannot perform as specified, the contractor shall be responsible for providing new to make the system perform as specified. The Owner takes no responsibility for the suitability and operation of existing equipment.
- 3.3.6 Supply and install all necessary accessories for the remote start-up of a pump or a fan, etc. These shall include relays, H.O.A. selectors, magnetic conductors interlock wiring, etc. All safety interlocks of the existing starters shall remain functional in both hand and auto positions. Where existing starters do not have H.O.A. selectors, contractor shall be responsible to retrofit/replace the starters and provide new.
- 3.3.7 Supply, install and render operational, primary control panel (SRPDC) and communications interface first. This shall be done to maintain the control and communication of the existing systems during the transfer from the existing DDC to the new control system.
- 3.3.8 All modifications to starters wiring are to be rewired while keeping only necessary interlocks. All redundant interlocks or relays shall be removed in their entirety (i.e. pneumatic fire heads where replaced with electrical/mechanical high limits controls, etc.).
- 3.3.9 Pneumatic Devices
 - 3.3.9.1 The owner does not intend to use any pneumatic devices within mechanical rooms (i.e. Damper and Valve Actuators). In some cases (where identified) field devices such as Thermostats/Valves in other areas of the building may remain as designated by the Owner/Consultant.
 - 3.3.9.2 In cases where the Owner/Consultant has designated to re-use pneumatic actuators and control devices, a pressure gauge (0-30 psi) shall be installed

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in the pneumatic line at the output of each electro-pneumatic transducer (EPT) and in the main compressed air line to the controller(s).

- 3.3.9.3 An in-line oil filter shall be installed in the main airline to each controller.
- 3.3.10 For replacement systems, the contractor shall provide a priority list at the start of the project indicating systems that are to be transferred first (from the old to the new control system) so that the building controls can be updated in a systematic and organized fashion. Consultant/Owner will review the list and provide any necessary input/changes.
- 3.3.11 The EMCS Contractor shall have all necessary thermo-wells for piping installed by a qualified mechanical contractor. Where existing thermometers are installed, the existing thermometer wells shall not be reused for DDC sensors. Strap-On sensors shall not be acceptable except where previously identified by the Consultant and/or Owner's representative. When new thermo-wells are to be installed in existing piping that is insulated, a length of one (1) foot of insulation shall be removed and redone adequately with new insulation of the same thickness and finish.
- 3.3.12 The Contractor shall be responsible for all the necessary patching and painting to make good the existing finish due to the removal of the existing equipment or the new installation.
- 3.3.13 Sequences of Operations
 - 3.3.13.1 The sequences of operations for all systems furnished in these specifications are generic in nature and are the expected sequence end results. (Refer **25 90 01 - EMCS: Site Requirements, Applications and System Sequences of Operation**)
 - 3.3.13.2 The Contractor shall make sure that the programming of the sequences of operations for the systems shall be such to prevent cycling at system start-up as well as cycling of the control actuators for the mixing dampers, cooling valves, heating valves, or other devices, etc.
 - 3.3.13.3 The Contractor shall foresee and include in his programming all necessary control loops, control modes, proportional bands, integration time, time delays for start-up, ramping, control loop reset and all other necessary details for the proper functioning of the system and in order to produce a stable control of the equipment.

3.4 QUALITY ASSURANCE

- 3.4.1 Ensure qualified supervisory personnel continuously direct and monitor Work and attend site meetings.
- 3.4.2 Health and Safety:
 - 3.4.2.1 Do construction occupational health and safety in accordance with Province of Ontario Occupation Health and Safety Act and city of Mississauga Health and Safety Requirements as a minimum.
- 3.4.3 Quality Control:

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- 3.4.3.1 Provide equipment and material from manufacturer's regular production, CSA certified, manufactured to standard quoted plus additional specified requirements.
- 3.4.3.2 Where CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.
- 3.4.3.3 Submit proof of compliance to specified standards with shop drawings and product data. Label or listing of specified organization is acceptable evidence.
- 3.4.3.4 In lieu of such evidence, submit certificate from testing organization, approved by Engineer/ Consultant and/or Owner, certifying that item was tested in accordance with their test methods and that item conforms to their standard/code.
- 3.4.3.5 For materials whose compliance with organizational standards/codes/specifications is not regulated by organization using its own listing or label as proof of compliance, furnish certificate stating that material complies with applicable referenced standard or specification.
- 3.4.3.6 Permits and fees: in accordance with general conditions of contract.
- 3.4.3.7 Submit certificate of acceptance from authority having jurisdiction to Engineer/ Consultant and/or Owner.
- 3.4.3.8 Existing devices intended for re-use (where specified): submit test report.

3.5 DELIVERY, STORAGE AND HANDLING

- 3.5.1 Material Delivery Schedule: provide schedule to Owner and/or Consultant/Engineer within 2 weeks after award of Contract.
- 3.5.2 Waste Management and Disposal:
 - 3.5.2.1 Separate waste materials for recycling in accordance with Specifications.
 - 3.5.2.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - 3.5.2.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material for recycling in accordance with Waste Management Plan.
 - 3.5.2.4 Separate for recycling and place in designated containers; Steel, Metal, Plastic, Paper waste in accordance with Waste Management Plan.
 - 3.5.2.5 Place materials defined as hazardous or toxic in designated containers.
 - 3.5.2.6 Handle and dispose of hazardous materials in accordance with Regional and Municipal, regulations.
 - 3.5.2.7 Label location of salvaged material's storage areas and provide barriers and security devices.
 - 3.5.2.8 Ensure emptied containers are sealed and stored safely.
 - 3.5.2.9 Divert unused materials from landfill to appropriate recycling facility as approved by Owner and/or Consulting/Engineer.

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- 3.5.2.10 Fold up metal and plastic banding, flatten and place in designated area for recycling.

3.6 MANUFACTURER'S RECOMMENDATIONS

- 3.6.1 Installation: to manufacturer's recommendations.

3.7 PAINTING

- 3.7.1 Clean and touch up marred or scratched surfaces of factory finished equipment to match original finish.
- 3.7.2 Restore to new condition, finished surfaces too extensively damaged to be primed and touched up to make good.
- 3.7.3 Clean and prime exposed hangers, racks, fastenings, and other support components.

END OF SECTION 25 01 11

EMCS: SUBMITTALS AND REVIEW PROCESS

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 3.1 NOT USED..... 4

EMCS: SUBMITTALS AND REVIEW PROCESS

Part 1 General

1.1 SUMMARY

- .1 Section Includes.
 - .1 Methods and procedures for shop drawings submittals, preliminary and detailed review process including review meetings, for building Energy Management Control System (EMCS).
- .2 Related Sections.
 - .1 Section 01 33 00 - Submittal Procedures.
 - .2 Section 25 05 01 - EMCS: General Requirements
 - .3 Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

1.2 DEFINITIONS

- .1 Acronyms and definitions: refer to Section 25 05 01 - EMCS: General Requirements

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures and coordinate with requirements of this Section.
- .2 Shop Drawings to consist of 3 hard copies and 1 soft copy of design documents, shop drawings, product data and software.
- .3 Hard copy to be completely indexed and coordinated package to assure compliance with contract requirements and arranged in same sequence as specification and cross-referenced to specification section and paragraph number.
- .4 Soft copy to be in PDF and/or EXEL format in accordance with owner's request, structured using menu format for easy loading and retrieval.
- .5 Receive from Owner and/or Consultant the job specific electronic version of the **City of Mississauga Points Matrix Form** as provided during project Tender. Vendor to populate all relevant columns and fields with necessary data including but not limited to; Point Names (in accordance with city of Mississauga Point Naming Convention), Point Type, Device Type, Controller Location and Power Source, etc.

1.4 SHOP DRAWING REVIEW

- .1 Submit shop drawings within 15 working days of award of contract and include, but not limited, following:
 - .1 Specification sheets for each item. To include manufacturer's descriptive literature, manufacturer's installation recommendations, specifications, drawings, diagrams, performance and characteristic curves, catalogue cuts, manufacturer's name, trade name, catalogue or model number, nameplate data, size, layout, dimensions, capacity, other data to establish compliance.
 - .2 Detailed system architecture showing all points associated with each controller including, signal levels, pressures where new EMCS ties into existing control equipment (where applicable)

EMCS: SUBMITTALS AND REVIEW PROCESS

- .3 Spare point capacity of each controller by number and type.
- .4 Controller locations.
- .5 Location of Power supply including Panel Name, Location, Circuit Numbers, etc.
- .6 Auxiliary control cabinet locations.
- .7 Single line diagrams showing cable routings, conduit sizes, spare conduit capacity between control centre, field controllers and systems being controlled.
- .8 Valves: complete schedule listing including following information: designation, service, manufacturer, model, point ID, design flow rate, design pressure drop, required Cv, Valve size, actual Cv, spring range, pilot range, required torque, actual torque and close off pressure (required and actual).
- .9 Dampers: sketches showing module assembly, interconnecting hardware, operator locations, operator spring range, pilot range, required torque, actual torque.
- .10 Flow measuring stations: complete schedule listing designation, service, point ID, manufacturer, model, size, velocity at design flow rate, manufacturer, model and range of velocity transmitter.
- .11 Wiring diagrams
- .12 Piping diagrams and hook-ups
- .13 Interface wiring diagrams showing termination connections and signal levels for equipment to be supplied by others
- .14 Shop drawings for each input/output point, sensors, transmitters, showing information associated with each particular point including
 - Sensing element type and location.
 - Transmitter type and range.
 - Associated field wiring schematics, schedules and terminations.
 - Completed **City of Mississauga Points Matrix Form**
 - Setpoints, curves or graphs and alarm limits (high and low, 3 types critical, cautionary and maintenance), signal range.
 - Software and programming details associated with each point.
 - Manufacturer's recommended installation instructions and procedures.
 - Input and output signal levels or pressures where new system ties into existing control equipment.
 - Control schematics, narrative description, CDL's fully showing and describing automatic and manual procedure required to achieve proper operation of project, including under complete failure of EMCS.
 - Graphic system schematic displays of all pages including Main Page, System Pages, Floor Plans, Terminal Equipment Quick Reference Pages, etc. including display Common elements, critical elements, all Navigation Links and menus as specified. (refer to Appendix A)
 - Complete system CDL's including companion English language explanations on same sheet but with different font and italics. CDL's to contain specified energy optimization programs (in Accordance with City of Mississauga format).

EMCS: SUBMITTALS AND REVIEW PROCESS

Part 2 Products

2.1 NOT USED

Part 3 Execution

3.1 NOT USED

END OF SECTION 25 05 02

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EMCS PROJECT RECORD DOCUMENTS

Part 1 General

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for final control diagrams and operation and maintenance (O&M) manual, for building Energy Management Control System (EMCS) Work.
- .2 Related Sections.
 - .1 Section 01 78 00 - Closeout Submittals.
 - .2 Section 25 05 01 - EMCS: General Requirements.
 - .3 Section 25 05 02 - EMCS: Submittals and Review Process.
 - .4 Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.
 - .5 Appendix A – City of Mississauga Forms and BAS Installation Guidelines

1.2 DEFINITIONS

- .1 OWS - Operator Workstation.
- .2 For acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 78 00 - Closeout Procedures, supplemented and modified by requirements of this Section.
- .2 Submit Acceptance Forms, Record Documents, As-built drawings, and Operation and Maintenance Manuals to Engineer and Owner in English.
- .3 Provide soft copies and hard copies in hard-back, 50 mm 3 ring, D-ring binders.
 - .1 Binders to be 2/3 maximum full.
 - .2 Provide index to full volume in each binder.
 - .3 Identify contents of each manual on cover and spine.
 - .4 Provide Table of Contents in each manual.
 - .5 Assemble each manual to conform to Table of Contents with tab sheets placed before instructions covering subject.

1.4 AS-BUILTS

- .1 Provide 1 copy of detailed shop drawings generated in Section 25 05 02 - EMCS: Submittals and Review Process and include:
 - .1 Changes to contract documents as well as addenda and contract extras.
 - .2 Changes to interface wiring.
 - .3 Routing of conduit, wiring and EMCS Subnetworks, control panel locations, power panel, and powers supply locations associated with EMCS installation.
 - .4 Locations of obscure devices to be indicated on drawings.
 - .5 Printed verification copy of received Critical alarm messages.

EMCS PROJECT RECORD DOCUMENTS

- .6 Panel/circuit breaker number for sources of normal/emergency power.
- .7 Names, addresses, telephone numbers of each sub-contractor having installed equipment, local representative for each item of equipment, each system.
- .8 Test procedures and reports: provide records of start-up procedures, test procedures, checkout tests and final commissioning reports as specified in Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.
- .9 Basic system design and full documentation on system configuration.
- .2 Submit for final review by Engineer and Owner.
- .3 Provide before acceptance 3 Hard and 1 soft copy incorporating changes made during final review.

1.5 O&M MANUALS

- .1 Custom design O&M Manuals (both hard and soft copy) to contain material pertinent to this project only, and to provide full and complete coverage of subjects referred to in this Section.
- .2 Provide 3 complete sets of hard and soft copies prior to system or equipment tests
- .3 Include complete coverage in concise language, readily understood by operating personnel using common terminology of functional and operational requirements of system. Do not presume knowledge of computers, electronics or in-depth control theory.
- .4 Functional description to include:
 - .1 Functional description of theory of operation.
 - .2 Design philosophy.
 - .3 Specific functions of design philosophy and system.
 - .4 Full details of data communications, including IP port and protocols required/in use, data types and formats, data processing and disposition data link components, interfaces and operator tests or self-test of data link integrity.
 - .5 Explicit description of hardware and software functions, interfaces and requirements for components in functions and operating modes.
 - .6 Description of person-machine interactions required to supplement system description, known or established constraints on system operation, operating procedures currently implemented for implementation in automatic mode.
- .5 System operation to include:
 - .1 Complete step-by-step procedures for operation of system including required actions at OWS.
 - .2 Operation of computer peripherals, input and output formats.
 - .3 Emergency, alarm and failure recovery.
 - .4 Step-by-step instructions for start-up, back-up equipment operation, execution of systems functions and operating modes, including keystrokes for each command so that operator need only refer to these pages for keystroke entries required to call up display or to input command.
- .6 Software to include:

EMCS PROJECT RECORD DOCUMENTS

- .1 Documentation of theory, design, interface requirements, functions, including test and verification procedures.
- .2 Detailed descriptions of program requirements and capabilities.
- .3 Data necessary to permit modification, relocation, reprogramming and to permit new and existing software modules to respond to changing system functional requirements without disrupting normal operation.
- .4 Software modules, fully annotated source code listings, error free object code files ready for loading via peripheral device
- .5 Complete program cross reference plus linking requirements, data exchange requirements, necessary subroutine lists, data file requirements, other information necessary for proper loading, integration, interfacing, program execution.
- .6 Software for each Controller and single section referencing Controller common parameters and functions.
- .7 Up-to-date security certifications.
- .7 Maintenance: document maintenance procedures including inspection, periodic preventive maintenance, fault diagnosis, repair or replacement of defective components, including calibration, maintenance, repair of sensors, transmitters, transducers, controller and interface firmware's, plus diagnostics and repair/replacement of system hardware.
- .8 System configuration document:
 - .1 Information regarding IP port and protocols required/in use
 - .2 Provisions and procedures for planning, implementing and recording hardware and software modifications required during operating lifetime of system.
 - .3 Information to ensure co-ordination of hardware and software changes, data link or message format/content changes, sensor or control changes in event that system modifications are required.

Part 2 Products

2.1 NOT USED

Part 3 Execution

3.1 NOT USED

END OF SECTION 25 05 03

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EMCS IDENTIFICATION

Part 1 General

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for identification of devices, sensors, wiring tubing, conduit and equipment, for building Energy Monitoring and Control System (EMCS) Work and nameplates materials, colours and lettering sizes.
- .2 Related Sections.
 - .1 Section 01 33 00 - Submittal Procedures.
 - .2 Section 25 05 01 - EMCS: General Requirements.
 - .3 Appendix A - City of Mississauga Standards and Guidelines
 - .4 Appendix B – City of Mississauga Forms and Templates
- .3 References
 - .1 Canadian Standards Association (CSA International).
CSA C22.1, The Canadian Electrical Code, Part I (19th Edition), Safety Standard for Electrical Installations.

1.2 DEFINITIONS

- .1 For acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements.

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit to Consultant for approval samples of nameplates, identification tags and list of proposed wording in accordance with City of Mississauga format (refer to Appendix A1).
- .3 All point names and point descriptors shall follow the City of Mississauga Point Naming Convention (refer to Appendix A1)

Part 2 Products

2.1 NAMEPLATES FOR CONTROL PANELS

- .1 Identify by Plastic laminate, 3 mm thick Melamine, matt white finish, black core, square corners, lettering accurately aligned and engraved into core.
- .2 Sizes: 25 x 67 mm minimum.
- .3 Lettering: minimum 7 mm high, black.
- .4 Inscriptions: machine engraved to identify function.
 - Example: RTU0102 (RPDC2903)

2.2 NAMEPLATES FOR FIELD DEVICES

- .1 Identify by plastic encased cards attached by plastic tie.
- .2 Sizes: 50 x 100 mm minimum.
- .3 Lettering: minimum 5 mm high in Black.

EMCS IDENTIFICATION

- .4 Data to include full point name and point address in accordance with **the City of Mississauga Point Naming Convention** (refer to Appendix A1).
 - Example: AHU0201_SF_SAT(RPDC5410)
- .5 Companion cabinet: identify interior components using plastic enclosed cards with point name and point address.

2.3 NAMEPLATES FOR ROOM SENSORS

- .1 Identify by stick-on labels using full point name identifier.
 - Example: AHU0201_RM205_T (TEC5411)
- .2 Location: On bottom portion of Room Sensor (as directed by Consultant and/or Owner).
- .3 Letter size: to suit, clearly legible.

2.4 WARNING SIGNS

- .1 Equipment including motors, starters under remote automatic control: supply and install orange coloured signs warning of automatic starting under control of EMCS.
- .2 Sign to read: "Caution: This equipment is under automatic remote control of EMCS".

2.5 WIRING

- .1 Supply and install markings on wiring at panels, junction boxes, splitters, cabinets, field devices and outlet boxes.
- .2 Identify all control wiring and communication trunks at both extremities using plastic, numbered clip-on wire markers and provide a legend at each controller (including terminal unit controllers) that identifies wires by number and full point descriptor (Per **City of Mississauga Point Naming Convention** – Appendix A1).
- .3 Colour coding: Use colour coded wiring throughout. Communications cables shall be of one color throughout system.
- .4 Power wiring: identify circuit breaker panel/circuit breaker number inside each EMCS panel.
 - Example: 120V Power – Fed from Panel LP-1, CCT - 10

2.6 CONDUIT

- .1 Colour code EMCS conduit.
- .2 Mark all EMCS junction box covers and conduit fittings.
- .3 Coding: use fluorescent orange paint and/or Owner approved Coding system.
- .4 Mark conduit at 1.5m intervals with Fluorescent tape. Also mark at point of entry and exit of each wall/partition.

2.7 PANEL ENCLOSURES

- .1 A professional printed/taped input/output layout sheet shall be mounted within each controller. This sheet shall be laminated and shall include:
 - .1 A panel layout diagram showing termination points of each controller and all devices within the panel (i.e. relays, expansion panels, transformers, etc.)

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- .2 The descriptor name of the points connected to each controller channel together with the revision number and date.
- .3 Designation of power source panel location and circuit number
- .2 All controllers and associated devices shall be identified with symbols relating directly to the control diagram.

2.8 CONCEALED CONTROL DEVICES

- .1 Label all control devices (i.e. Heat Pumps, VAV Boxes, Fan Coils, room thermostats, relays, transformers, panels, etc.) in the field with proper descriptors and where concealed above ceilings, etc. - identify on the ceiling grid below where the devices are located with Lamacoid Label

Part 3 Execution

3.1 NAMEPLATES AND LABELS

- .1 Ensure that manufacturer's nameplates, CSA labels and identification nameplates are visible and legible at all times.

3.2 EXISTING PANELS

- .1 Correct/replace existing nameplates and legends to reflect changes made during Work.

END OF SECTION 25 05 54

EMCS WARRANTY AND MAINTENANCE

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EMCS WARRANTY AND MAINTENANCE

Part 1 General

1.1 SUMMARY

- .1 Section Includes.
 - .1 Requirements and procedures for warranty and activities during warranty period and service contracts, for building Energy Management Control System (EMCS).
- .2 Related Sections.
 - .1 Section 01 33 00 - Submittal Procedures.
 - .2 Section 01 78 00 - Closeout Submittals.
 - .3 Section 25 05 01 - EMCS: General Requirements.
 - .4 Appendix A – City of Mississauga Forms and BAS Guidelines
- .3 References.
 - .1 Canada Labour Code (R.S. 1985, c. L-2)/Part I - Industrial Relations.
 - .2 Canadian Standards Association (CSA International).
 - .1 CSA Z204-Latest Addition, Guidelines for Managing Indoor Air Quality in Office Buildings.

1.2 DEFINITIONS

- .1 For acronyms and definitions refer to Section 25 05 01 - EMCS: General Requirements

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit detailed preventative maintenance schedule for system components to Owner's Representative.
- .3 Submit detailed EMCS inspection reports to Owner's Representative.
- .4 Submit dated, maintenance task lists to Owner's Representative and include the following sensor and output point detail, as proof of system verification:
 - .1 Point name and location.
 - .2 Device type and range.
 - .3 Measured value.
 - .4 System displayed value.
 - .5 Calibration detail
 - .6 Indication if adjustment required,
 - .7 Other action taken or recommended
- .5 Complete and submit a full network analysis report. Report shall identify results of analysis with detailed recommendations to correct any problems found.
- .6 Records and logs

EMCS WARRANTY AND MAINTENANCE

- .1 Maintain records and logs of each maintenance task on site.
- .2 Organize cumulative records for each major component and for entire EMCS chronologically.
- .3 Submit records to Owner's Representative, after inspection indicating that planned and systematic maintenance have been accomplished
- .4 Revise and submit to Owner's Representative in accordance with Section 01 78 00 - Closeout Submittals "As-built drawings" documentation and commissioning reports to reflect changes, adjustments and modifications to EMCS made during warranty period

1.4 MAINTENANCE SERVICE DURING WARRANTY PERIOD

- .1 Provide services, materials, and equipment to maintain EMCS for specified warranty period.
- .2 Emergency Service Calls:
 - .1 Initiate service calls when EMCS is not functioning correctly.
 - .2 Qualified control personnel to be available during warranty period to provide service to "CRITICAL" components whenever required at no extra cost.
 - .3 Furnish Owner with telephone number where service personnel may be reached at any time.
 - .4 Service personnel to be on site ready to service EMCS within 2 hours after receiving request for service (refer to 1.5.1 of this Section)
 - .5 Perform Work continuously until EMCS restored to reliable operating condition.
- .3 Operation: foregoing and other servicing to provide proper sequencing of equipment and satisfactory operation of EMCS based on original design conditions and as recommended by manufacturer.
- .4 Work requests: record each service call request, when received separately on City of Mississauga approved form and include:
 - .1 Serial number identifying component involved.
 - .2 Location, date and time call received.
 - .3 Nature of trouble.
 - .4 Names of personnel assigned.
 - .5 Instructions of work to be done.
 - .6 Amount and nature of materials used.
 - .7 Time and date work started.
 - .8 Time and date of completion.
- .5 Provide system modifications in writing.
- .6 No system permanent modification, including operating parameters and control settings, to be made without approval of Engineer/Consultant and/or Owner.

1.5 WARRANTY

- .1 **Scope of Warranty:** The Contractor shall guarantee the proper functioning of all the work and the installation regarding his contract for a period of one year, effective as the provisional acceptance of the work of the Owner. The Contractor shall replace or repair, at his discretion,

EMCS WARRANTY AND MAINTENANCE

both immediately and free of charge and all the devices, pieces of equipment or material found defective during this period. This warranty covers material and labour including but not limited to:

- .1 All expenses generated from the imperfect execution of the work, poor maintenance, repair or replacement.
 - .2 Emergency service calls during the warranty period (available 24 hours/day, 7 days/week, and 52 weeks/year) within a 2-hour response time.
 - .3 Replacement of all defective pieces and components.
 - .4 Correction to any and all programming where the performances are not in conformity with the rules of the trades.
- .2 Warranty of Perfect Execution of the Work
- .1 Owner shall hold an equivalent amount of 5% of the cost of the work without interest for a period of six (6) months following the provisional acceptance date of the work, as a warranty of perfect execution of the work.
 - .2 Neither the holdback nor its payment shall free the Contractor from the legal responsibilities he is incumbent upon. Consultant shall use this amount of money to execute the repair that the Contractor neglects or refuses to do within five (5) days following a written notice from the Owner to this concern.
- .3 Intermittent Defects
- .1 If during the warranty period, intermittent defects or abnormal phenomena are detected, that fail under the Contractor's responsibility, the period of the warranty shall be extended for a period equivalent to the time loss of system functionality caused by these defects or phenomena.
- .4 The Contractor's Responsibility
- .1 Any operational defect which may appear in any of the work and occurring during the period and according to the judgement of Council is not due to a misuse of the Owner and/or an ordinary wear and tear but a deficiency in the material or in the installation work and /or programming shall be repaired by the Contractor without any additional expenses to Owner or Consultant. The Contractor shall also assume any costs to compensate for any injuries or other work that the defect may have caused. All repairs done by the Contractor, during the warranty period, shall be done after peak working hours in the concerned areas and causing minimum inconveniences to the Owner.
 - .2 Inspection and acceptance of the work and materials, the payments made and the use of equipment by the users shall not diminish the Contractors' responsibilities. The general warranty shall not exempt, in any case, any particular warranty, otherwise stipulated and shall not affect any warranty provided in terms of the established laws.
- .5 Renewal of Software
- .1 If the Contractor makes any upgrade to their represented EMCS system and/or the EMCS software, it shall be made available to Owner and installed on the server and/or system controllers. The new editions of software updates which can be incorporated to the existing installed equipment shall be supplied and installed **free of charge** to the Owner for a period of five (5) years from date of initial installation. Contractor shall notify owner in writing 12 months prior to the end of the five (5) year software service

EMCS WARRANTY AND MAINTENANCE

period and offer a re-subscription with a stipulated price. (This applies to both JACE and Field Controllers)

- .2 Maintenance of security certifications is required during both the original and extended warranty periods as described above.

.6 Preventive Maintenance

- .1 Preventive maintenance is not considered as part of the warranty.
- .2 Preventive maintenance forms part of Service Contracts which is an optional decision by the Owner.

1.6 WARRANTY EXTENSION

- .1 The Contractor may be asked during individual tender to submit a separate price for an additional warranty contract (for services, pieces, repair/replacement offered to the Owner), for a period of twelve (12) months, effective at the end of the warranty of the present contract.
 - .1 Maintenance of security certifications is required during any extended warranty periods

1.7 SERVICE CONTRACTS

- .1 Provide in-depth technical expertise and assistance to Owner's Representative and Commissioning Agent in preparation and implementation of service contracts and in-house preventive maintenance procedures. Service contracts duration is for the warranty period.
- .2 Service Contracts to include:
 - .1 Annual verification of field points for operation and calibration.
 - .2 Four (4) service visits per year.
 - .3 Two (2) hour response to all daytime emergency calls.
 - .4 Two (2) hour response to all emergency calls during silent hours.
 - .5 Silent hours defined as 1630 h – 0800 h and on weekends and statutory holidays.
 - .6 Complete inventory of installed system.

Part 2 Products

2.1 NOT USED

Part 3 Execution

3.1 FIELD QUALITY CONTROL

- .1 Work must be approved by a City of Mississauga staff and receive a proper work order number at least 3 days prior to the inspections. Any work without a proper work order number shall be considered as a free of charge service.

EMCS WARRANTY AND MAINTENANCE

- .2 Perform as minimum (3) three minor inspections and one major inspection (more often if required by manufacturer) per year. Provide detailed written report to Owner's Representative as described in Submittal article.
- .3 Perform inspections during regular working hours, 0800 to 1630 h, Monday through Friday, excluding statutory holidays.
- .4 Following inspections are minimum requirements and should not be interpreted to mean satisfactory performance:
 - .1 Perform calibrations using test equipment having traceable, certifiable accuracy at minimum 50% greater than accuracy of system displaying or logging value.
 - .2 Check and calibrate random sample of 10% field input/output devices in accordance with Canada Labour Code - Part I and CSA Z204.
 - .3 Provide dated, maintenance task lists, as proof of execution of complete system verification
- .5 Minor inspections to include, but not limited to:
 - .1 Perform visual, operational checks to Control Panels, peripheral equipment, interface equipment and other panels.
 - .2 Check equipment cooling fans as required.
 - .3 Visually check for mechanical faults, air leaks and proper pressure settings on pneumatic components.
 - .4 Review system performance with Operations Supervisor and/or Owner's Representative to discuss suggested or required changes.
- .6 Major inspections to include, but not limited to:
 - .1 Minor inspection.
 - .2 Clean OWS(s) peripheral equipment, Control Panels, interface and other panels, micro-processor interior and exterior surfaces.
 - .3 Check signal, voltage and system isolation of Control Panels, peripherals, interface and other panels.
 - .4 Verify calibration/accuracy of each input and output device and recalibrate or replace as required (as per 3.1. 4.2).
 - .5 Run system software diagnostics as required.
 - .6 Install all software and firmware enhancements (including those required by the EMCS LAN equipment) to ensure components are operating at most current revision for maximum capability and reliability.

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- .7 Perform network analysis and provide report as described in Submittal article.
- .8 Rectify deficiencies revealed by maintenance inspections and environmental checks.
- .9 Continue system debugging and optimization.
- .10 Testing/verification of occupancy and seasonal-sensitive systems to take place during four (4) consecutive seasons, after facility has been accepted, taken over and fully occupied.
- .11 Test weather-sensitive systems twice: first at near winter design conditions and secondly under near summer design conditions.

END OF SECTION 25 08 20

EMCS LOCAL AREA NETWORK

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Part 3 Execution 4

 3.1 NETWORK/COMMUNICATION CABLING 4

EMCS LOCAL AREA NETWORK

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 System requirements for Local Area Network (LAN) for Building Energy Management Control System (EMCS).
- .2 Related Sections:
 - .1 Section 25 05 01 - EMCS: General Requirements.
- .3 References
 - .1 Canadian Standards Association (CSA International).
 - .1 CSA T529 Telecommunications Cabling Systems in Commercial Buildings (Adopted ANSI/TIA/EIA-568-A with modifications).
 - .2 CSA T530 , Commercial Building Standard for Telecommunications Pathways and Spaces (Adopted ANSI/TIA/EIA-569-A with modifications).
 - .2 Institute of Electrical and Electronics Engineers (IEEE)/Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements.
 - .1 IEEE Std 802.3TM, Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.
 - .3 Telecommunications Industries Association (TIA)/Electronic Industries Alliance (EIA)
 - .1 TIA/EIA-568-, Commercial Building Telecommunications Cabling Standards Set, Part 1 General Requirements Part 2 Balanced Twisted-Pair Cabling Components Part 3 Optical Fiber Cabling Components Standard.
 - .2 TIA/EIA-569-A, Commercial Building Standard for Telecommunications Pathways and Spaces

1.2 DEFINITIONS

- .1 Acronyms and definitions: refer to Section 25 05 01 - EMCS - General Requirements.

1.3 SYSTEM DESCRIPTION

- .1 Data communication network to link Supervisory Remote Digital Control Panel (SRPDC) to Remote Digital Control Panels (RPDC), Terminal Equipment Controllers (TEC) and OEM Application Specific Controllers (OEMASC) in accordance with CSA T529 and CSA T530.
 - .1 Provide reliable and secure connectivity of adequate performance between different sections (segments) of network.
 - .2 Allow for future expansion of network, with selection of networking technology and communication protocols.
- .2 Data communication network to include, but not limited to:
 - .1 EMCS-LAN.
 - .2 Network interface cards.
 - .3 Network management hardware and software.

EMCS LOCAL AREA NETWORK

- .4 Network components necessary for complete network.

1.4 DESIGN REQUIREMENTS

- .1 EMCS Local Area Network (EMCS-LAN).
 - .1 High speed, high performance, local area network over which SRPDC, and RPDC communicate with other directly on peer to peer basis in accordance with CSA T529 and T530.
 - .2 EMCS-LAN (RPDC to RPDC and/or SPRDC): BACNet IP Communication Protocol
 - .3 EMCS-SUBLAN (RPDC to TEC): BACnet IP Communication Protocol and/or BACnet MS/TP Communication Protocol as indicated in project specific specifications.
 - .4 Each EMCS-SUB LAN to be capable of supporting at minimum of 100 devices.
 - .5 High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, upload/download information between network devices. Bit rate to be 10 Megabits per second minimum.
 - .6 Detection and accommodation of single or multiple failures of either SRPDC, RPDC, TEC, OEMASC or network media. Operational equipment to continue to perform designated functions effectively in event of single or multiple failures.
 - .7 Commonly available, multiple sourced, networking components and protocols to allow system to co-exist with other networking applications including office automation.
- .2 Dynamic Data Access.
 - .1 LAN to provide capabilities for OWSs, either network resident or connected remotely, to access point status and application report data or execute control functions for other devices via LAN.
 - .2 Access to data to be based upon logical identification of building equipment.
- .3 Network Medium.
 - .1 Network Medium (EMCS LAN): Ethernet Cable(IP) CAT 5,6,6E
 - .2 Network Medium (EMCS SUBLAN): Ethernet Cable(IP) CAT 5,6,6E or shielded twisted cable, compatible with network protocol to be used within buildings (as indicated in Project specifications).
- .4 EMCS Switch/Router
 - .1 Vendor is to supply and install all necessary Switches/Routers for a complete EMCS network separate and distinct from the building's IT LAN.
 - .2 Switches/Routers are to be installed in a lockable Cabinet Enclosure Marked EMCS with dedicated power supplies.
- .5 Network Security
 - .1 Security protocols of the EMCS LAN shall meet or exceed the requirements of the City of Mississauga Information Technology Services department

EMCS LOCAL AREA NETWORK

Part 2 Products

2.1 COMMUNICATION WIRING HANGERS

- .1 Provide Communication system wiring hangers to supplement existing hangers such that communications cable maximum span is 4m for change in direction of greater than 45 degrees or 9m for a straight run
- .2 Hangers are to be suitable for supporting up to 80 4-pair UTO low voltage cables with 50mm diameter loop. Provide multiple hangers on single support bracket as shown on detail drawing. Erico No. CAT32.
- .3 Provide all required 10mm threaded hangers, rods, bolts, wall anchors, beam clamps and fittings as required for proper installation and support.
- .4 Manufacturers: Caddy, B-Line, Approved Equal.

Part 3 Execution

3.1 NETWORK/COMMUNICATION CABLING

- .1 EMCS communication BUS (between SRPDC and all field panels) shall be in EMT Conduit where exposed, and in plenum rated cable (FT 6) above rated ceiling plenums. Where EMCS network is run outside of conduit it must be neatly run with new communication hangers (where they are pre-existing, communication hangers be re-used).
- .2 All Communication cable shall be of the same color with label at extremities indicating LAN identification, termination point and where applicable Switch and Port. Ethernet cable shall be Orange.
- .3 Where there are insufficient hangers or structure existing, contractor shall install hangers to accommodate a maximum distance between strapping points of 4m (for change in direction of greater than 45 degrees) or 9m for a straight run.
- .4 Where Ethernet communications for EMCS sub-network have been permitted, ethernet cable shall be in conduit throughout. EMCS Vendor shall supply designated EMCS Switch/Router and assign all sub-network addresses needed to communicate to controllers and OEMASC.
- .5 EMCS Switch/Router shall be installed in a latched NEMA Rated cabinet within mechanical/electrical rooms
- .6 Communications conduits to be minimum 21mm EMT maximum 50% full.
- .7 In general, the following table shall be used for conduit sizing:

Conduit Size:	21mm	27mm	35mm	41mm
Max UTP	2	3	6	7
- .8 Cables shall not be attached to pipe, conduit or ductwork, etc.
- .9 Conduit ends shall be provided with non-metallic bushing to provide a round edge which will not abrade the cable jacket.

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END OF SECTION 25 10 01

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Part 1 General

1.1 SUMMARY

1.1.1 Section Includes:

- 1.1.1.1 Materials and installation for building automation controllers including:
 - 1.1.1.1.1 Supervisory Remote Programmable Digital Controller (SRPDC).
 - 1.1.1.1.2 Remote Programmable Digital Controller (RPDC)
 - 1.1.1.1.3 Terminal Equipment Controllers (TEC)
 - 1.1.1.1.4 Original Equipment Manufacturer Application Specific Controllers (OEMASC)

1.1.2 Related Sections:

- 1.1.2.1 Section 25 05 01 - EMCS: General Requirements.
- 1.1.2.2 Section 25 05 02 - EMCS: Submittals and Review Process.
- 1.1.2.3 Section 25 05 54 – EMCS: Identification
- 1.1.2.4 Section 25 05 03 - EMCS: Project Record Documents.
- 1.1.2.5 Section 25 30 02 - EMCS: Field Control Devices.
- 1.1.2.6 Section 25 90 01 - EMCS: Site Requirements Applications and Systems Sequences of Operation.

1.1.3 References

- 1.1.3.1 American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. (ASHRAE)
 - 1.1.3.1.1 ASHRAE, Applications Handbook, SI Edition.
- 1.1.3.2 Canadian Standards Association (CSA International)
 - 1.1.3.2.1 C22.2 No.205-M1983(R1999), Signal Equipment.
- 1.1.3.3 Institute of Electrical and Electronics Engineers (IEEE)
 - 1.1.3.3.1 IEEE C37.90.1-02, Surge Withstand Capabilities (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.

1.2 DEFINITIONS

- 1.2.1 Acronyms and definitions: refer to Section 25 05 01 - EMCS: General Requirements.

1.3 SYSTEM DESCRIPTION

- 1.3.1 General: Network of controllers comprising of SRPDC, RPDC, TEC, OEMASC to be provided as indicated in System Architecture and Standard Wiring Diagram to support building systems and associated sequence(s) of operations as detailed in these specifications.
 - 1.3.1.1 Provide sufficient controllers to meet intents and requirements of this section.
 - 1.3.1.2 Controller quantity, and point contents to be approved by Consultant at time of preliminary design review.

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1.3.2 Controllers: stand-alone intelligent Control Units.

- 1.3.2.1 Incorporate programmable microprocessor, non-volatile program memory, RAM, power supplies, as required to perform specified functions.
- 1.3.2.2 Incorporate communication interface ports for communication to LANs to exchange information with other Controllers.
- 1.3.2.3 Capable of interfacing with operator interface device.
- 1.3.2.4 Execute its logic and control using primary inputs and outputs connected directly to its onboard input/output field terminations or slave devices, and without need to interact with other controllers
 - 1.3.2.4.1 Secondary input used for reset such as outdoor air temperature may be located in other Controller(s).

1.4 SUBMITTALS

- 1.4.1 Provide submittals in accordance with Section 01 33 00 Submittal Procedures and Section 25 05 02 - EMCS: Submittals and Review Process.
- 1.4.2 Submit product data sheets for each product item proposed for this project.

1.5 DESIGN REQUIREMENTS

1.5.1 To include:

- 1.5.1.1 Scanning of AI and DI connected inputs for detection of change of value and processing detection of alarm conditions.
- 1.5.1.2 Perform On-Off digital control of connected points, including resulting required states generated through programmable logic output.
- 1.5.1.3 Perform Analog control using programmable logic, (including PID) with adjustable dead bands and deviation alarms.
- 1.5.1.4 Control of systems as described in sequence of operations.
- 1.5.1.5 Execution of optimization routines as listed in this section.

1.5.2 Total spare capacity for RPDC: at least 25 % of each point type (distributed throughout the RPDC's within each mechanical/electrical room) unless directed otherwise during tender.

1.5.3 Field Termination and Interface Devices:

- 1.5.3.1 To: CSA C22.2 No.205.
- 1.5.3.2 Electronically interface sensors and control devices to processor unit.
- 1.5.3.3 Include, but not be limited to, following:
 - 1.5.3.3.1 Programmed firmware or logic circuits to meet functional and technical requirements.
 - 1.5.3.3.2 Power supplies for operation of logics devices and associated field equipment.
 - 1.5.3.3.3 Lockable wall cabinet.
 - 1.5.3.3.4 Required communications equipment and wiring (if remote units).

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- 1.5.3.3.5 Leave controlled system in "fail-safe" mode in event of loss of communication with, or failure of, processor unit.
- 1.5.3.3.6 Input Output interface to accept as minimum AI, AO, DI, DO functions as specified.
- 1.5.3.3.7 Wiring terminations: use conveniently located screw type or spade lug terminals.
- 1.5.3.4 AI interface equipment to:
 - 1.5.3.4.1 Convert analog signals to digital format with 10 bit analog-to-digital resolution.
 - 1.5.3.4.2 Provide for following input signal types and ranges:
 - 4 - 20 mA;
 - 0 - 10 V DC;
 - 100/1000-ohm RTD input;
 - 1.5.3.4.3 Meet IEEE C37.90.1 surge withstand capability.
 - 1.5.3.4.4 Have common mode signal rejection greater than 60 dB to 60 Hz.
 - 1.5.3.4.5 Where required, dropping resistors to be certified precision devices which complement accuracy of sensor and transmitter range specified.
- 1.5.3.5 AO interface equipment:
 - 1.5.3.5.1 Convert digital data from controller processor to acceptable analog output signals using 8-bit digital-to-analog resolution.
 - 1.5.3.5.2 Provide for following output signal types and ranges:
 - 4 - 20 mA.
 - 0 - 10 V DC.
 - 1.5.3.5.3 Meet IEEE C37.90.1 surge withstand capability.
- 1.5.3.6 DI interface equipment:
 - 1.5.3.6.1 Able to reliably detect contact change of sensed field contact and transmit condition to controller.
 - 1.5.3.6.2 Meet IEEE C37.90.1 surge withstand capability.
 - 1.5.3.6.3 Accept pulsed inputs up to 2 kHz.
- 1.5.3.7 DO interface equipment:
 - 1.5.3.7.1 Respond to controller processor output, switch respective outputs. Each DO hardware to be capable of switching up to 0.5 amps at 24 V AC.
 - 1.5.3.7.2 Switch up to 5 amps at 220 V AC using optional interface relay.
- 1.5.4 Controllers and associated hardware and software: operate in conditions of 0°C to 44°C and 20 % to 90 % non-condensing RH.
- 1.5.5 Controllers (SRPDC & RPDC): mount in **NEW** NEMA 1 wall mounted cabinet with hinged, keyed-alike locked door.
 - 1.5.5.1 Provide for conduit entrance from top, bottom or sides of panel.
 - 1.5.5.2 Except where otherwise noted, TEC's to be mounted inside a separate NEMA rated enclosure in nearest designated mechanical/electrical room. Wiring from enclosure to terminal equipment shall be in EMT conduit

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(including the portion above ceiling system) with liquid tight conduit for the last 24-30" only.

- 1.5.5.3 All the controllers and panels to be installed eye level height, to be accessed without using ladder or stool, not behind doors or any mechanical equipment, in a way that panel door can be fully opened without restriction. With some exception for direct mounting controller (such as VAV box) unless otherwise approve by COM.
- 1.5.6 Cabinets to provide protection from dust water dripping from above, while allowing sufficient airflow to prevent internal overheating. For installations in dusty areas (ie – Transit Garage), cabinet enclosure will accommodate air filtration for cabinet venting.
- 1.5.7 Provide surge and low voltage protection for interconnecting wiring connections.

1.6 MAINTENANCE PROCEDURES

- 1.6.1 Provide manufacturers recommended maintenance procedures for insertion in Section 25 05 03 - EMCS: Project Record Documents.

Part 2 Products

2.1 SUPERVISORY REMOTE PROGRAMMABLE DIGITAL CONTROLLER (SRPDC)

- 2.1.1 The SRPDC is BAC-Net Compliant, stand-alone and fully user- programmable supervisory controller. The SRPDC shall comply with all mentioned EMCS System requirements and shall monitor the network of distributed application specific remote digital controllers (RPDC). The SRPDC shall communicate on a peer-to-peer basis across the Owners Ethernet network with the other SRPDC Controllers and to a Central Enterprise Server.
- 2.1.2 The SRPDC shall use one (or several) micro-computer(s) with sufficient memory to:
 - 2.1.2.1 Acquire, process, and transfer data to the Owner's Enterprise Server OR OTHER SRPDC.
 - 2.1.2.2 Accept, process, and execute orders coming from the Enterprise Server or other input devices;
 - 2.1.2.3 Record, analyze, and signal the change of state or value that appears among the connected RPDC controllers to the SRPDC;
 - 2.1.2.4 Access to any one SRPDC shall allow the user to gain access any other SRPDC on the owner's network without need to go through the Owner's server.
 - 2.1.2.5 The SRPDC shall have the capability of generating and storing HTML5 Scalable Vector Graphics. NOTE: System Graphics for each Site shall reside on the server with secondary copies downloaded to the SRPDC on Site. A secondary back-up copy of all graphics shall also be automatically updated with each change and stored on the Owner's designate Enterprise Server.

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- 2.1.3 Every SRPDC shall execute continuous diagnostics and all function failures shall be enunciated at one or more designated operator's workstations. Failure of an SRPDC shall not affect the function of the Server or any other SRPDC on the network.
- 2.1.4 If the EMCS Enterprise Server or network transmission fails, the SRPDC shall continue to control all the changes of state and/or value and shall have sufficient memory to store the readings of all analog inputs and the calculated values of the SRPDC for a minimum of 12 hours. After the failure, the SRPDC shall send the stored readings to the EMCS Enterprise Server.
- 2.1.5 Intervals between each reading shall depend on the type of reading and shall be determined by the Owner designated user(s) through commands established in the EMCS Enterprise Server Software.
- 2.1.6 These time intervals shall be adjustable and defined by the user and shall be selected based on the real capacities of the SRPDC provided by the supplier.
- 2.1.7 Each SRPDC shall function on a common communication bus line between different RPDC's on a peer-to-peer basis and shall provide real-time clock functions for scheduling and network time synchronization. The SRPDC shall be able to communicate with the Server in a selective manner and in a way to maintain stand-alone operation of the SRPDC.
 - 2.1.7.1 The SRPDC shall be able to communicate with the COM network for network time synchronization
- 2.1.8 If there is a power failure, the SRPDC shall have sufficient memory to support its operating system, database, programming requirements. Battery shall maintain the static RAM memory and clock functions for minimum of 72 hours.
- 2.1.9 The SRPDC operating system, field database, and application programs shall reside in EEPROM.
- 2.1.10 The run time field data and values shall reside in battery backed-up on board memory or RAM.
- 2.1.11 SRPDC shall be **Tridium JACE 8000 Series controller**. Contractor shall provide required number of SPRDC(s) designed to manage the number of points and controllers on the specific site.
- 2.1.12 All data including programming and graphics shall be backed up by the contractor at the EMCS Enterprise Server upon completion of every change to the system.

2.2 REMOTE PROGRAMMABLE DIGITAL CONTROLLERS (RPDC)

- 2.2.1 Each RPDC shall be fully user-programmable, digital controller that communicates via MS/TP Bus supporting BAC-net Standard protocol ANSI/ASHRAE 135 2004.
- 2.2.2 The RPDC shall be factory programed with a continuous adaptive tuning algorithm that detects changes in the physical environment and continually adjusts loop tuning parameters suitably. Controllers that require manual tuning of loops or perform tuning on command only shall not be acceptable.
- 2.2.3 The RPDC shall provide a remote annunciation of any detected component failure, low battery conditions or repeated failure to establish communication.

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- 2.2.4 Each RPDC shall incorporate direct digital control and shall operate as an independent control unit capable of distributed processing functions as described hereafter. It shall furnish real direct digital control replacing the transmitters and the existing analog controllers.
- 2.2.5 Each RPDC shall work as an independent unit and shall continue to operate independently even if the other parts of the system including the SRPDC and/or Enterprise Server are not operational.
- 2.2.6 RPDC shall have the following characteristics:
 - 2.2.6.1 Automatic start-up after a power failure
 - 2.2.6.2 Controller set-point reset, locally or remotely through the EMCS Enterprise Server and position readjustment of the controlled devices
 - 2.2.6.3 The RPDC shall include troubleshooting LED indicators to identify conditions i.e. Power ON/OFF, Device fault, No fault, normal operation etc.
 - 2.2.6.4 User capacity to define all the operational characteristics of each control loop by means of keyboard commands of a man-machine interface (MMI)
 - 2.2.6.5 User capacity to define the control modes such as: proportional, integral, derivative, square error, and adaptive functions in response to the network needs;
 - 2.2.6.6 Clear communication language oriented toward process control and not done in computer jargon
 - 2.2.6.7 User capacity to define the operation logic such as: and/or equal to/unequal to, and greater than/less than
 - 2.2.6.8 Self-diagnostics
 - 2.2.6.9 Energy management functions (ex: optimal start/stop, enthalpy control, electric load shedding control, etc.
 - 2.2.6.10 Library of control routines and program logic to perform the sequence of operation.
 - 2.2.6.11 Contain sufficient memory to support its own operating system, database and have at least 25% of the memory available for future use.
 - 2.2.6.12 In the event of the loss of normal power, there shall be an orderly shutdown of all digital controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for minimum of 72 hours.
 - 2.2.6.13 Upon restoration of normal power, the RPDC shall automatically resume full operation without manual intervention.
 - 2.2.6.14 Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24 Volts floating control, 3-15 psi pneumatic, 0-10VDC or 20 mA, allowing for interface to a variety of modulating actuators.

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- 2.2.6.15 All controller sequences and operation shall provide closed loop control of the intended application. Controlling by another upstream RPDC over the local field network is not acceptable.

2.3 TERMINAL EQUIPMENT CONTROLLERS (TEC)

- 2.3.1 TEC shall be utilized for control of each piece of terminal equipment including but not limited to the following:
- Variable Air Volume (VAV) boxes
 - Constant Air Volume (CAV) boxes with reheat
 - Dual Duct Terminal Boxes
 - Unit Air conditioners
 - Heat Pumps
 - Unit Ventilators
 - Fan Coils
 - Room and or Laboratory Pressurization
- 2.3.2 TEC's shall include all point inputs and outputs necessary to perform the specified control sequences for associated terminal equipment. Analog outputs shall be industry standard signals such as 24 Volts floating point control, 0-10VDC or 4-20 mA, allowing for interface to a variety of modulating actuators.
- 2.3.3 All TEC sequences and operation shall provide closed loop control of the intended application.
- 2.3.4 Controlling terminal equipment by another upstream RPDC controller over the local field network is not acceptable.

2.4 ORIGINAL EQUIPMENT MANUFACTURER APPLICATION SPECIFIC CONTROLLERS (OEMASC)

- 2.4.1 The EMCS shall extend communication and operation through the integration of OEM Application Specific Controllers (OEMASC) via a dedicated BACNet Field BUS connected to the SRPDC.
- 2.4.2 Each OEMASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of all other controllers in the network. Each OEMASC shall include a microprocessor-based, multi-tasking, and real time digital control processor.
- 2.4.3 As listed in 2.4.1, the OEMASC are to reside on a dedicated EMCS Subnetwork, connected directly to the SRPDC and only communicating to OEMASC (i.e. – no other field controllers to reside on this network).
- 2.4.4 Equipment supplied with OEMASC may include:
- Chillers,
 - Heat pumps,
 - Gas fired furnaces,
 - Boilers
 - VFD's
 - Rooftop Units

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- Utility Meters/Sub Meters
- Lighting Controls
- Variable Refrigerant Flow (VRF) systems
- Heat Recovery Ventilators
- Chemical/Gas detector
- Air/Refrigeration Compressors
- Dehumidifiers
- Generators
- Humidifiers
- Overhead Doors
- Spray Pads
- Other equipment that come with OEM Installed On-board micro-processor controls.

- 2.4.5 The OEMASC shall include all points (inputs and outputs) necessary to perform the specified control sequences and shall be the responsibility of the Equipment supplier. Integration of the OEMASC to the EMCS shall require programming representatives of both systems to be present on site at the time of set-up to ensure all BACNet and/or other communication protocols are set up and mapped to the EMCS with proper priority to ensure specified sequence of operation is met.

2.5 HARDWARE CONFIGURATION AND CONSTRUCTION

- 2.5.1 Each SRPDC and associated RPDC's shall include a lockable cabinet, power supply, electronic cards, and termination modules, all CSA and ULC approved.
- 2.5.2 Each SRPDC and RPDC shall operate in an ambient environment of -10 °C to 35°C and 10% to 90% relative humidity.
- 2.5.3 Each SRPDC, RPDC and TEC shall be protected to eliminate transitory high voltage, electromagnetic noises, radio frequency interference (ex.: interferences caused by walkie-talkies).
- 2.5.4 The SRPDC, RPDC and TEC shall have integral power switch. If the device manufacturer does not provide an on-board power switch, then the System Contractor shall provide a separate dedicated transformer and switch within each enclosure for each controller.
- 2.5.5 The SRPDC, RPDC and TEC shall provide diagnostic LEDs for power, communications and microprocessor status i.e. device fault, normal data transmission, Download or start up in progress & not ready for normal operation. All programming sequences shall be stored in non-volatile memory.
- 2.5.6 Each RPDC and TEC shall contain both software and firmware to perform full DDC PID control loops.
- 2.5.7 Each controller type shall be able to support various types of zone temperature sensors, such as temperature sensor only, temperature sensor with built-in local override switch, with set point adjustment switch, temperature sensor with CO2 monitor or temperature sensor with occupancy switch.

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- 2.5.8 Each TEC controller for VAV/CAV application shall have a built-in air flow transducer for accurate air flow measurements in order to provide the pressure independent VAV operation. If the transducer is not internal to the controller, the controller/transducer assembly shall be factory tested and approved for the intended use.
- 2.5.9 Astronomical Time: Astronomical capability shall allow the system to calculate sunrise and sunset times based on geographical location, and incorporate Daylight Savings Time, for dusk-to dawn control or dusk-to time control. This is required in any DDC controller with I/O for exterior lighting circuit(s) .The DDC controller may receive this value from SRPDC or RPDC and fail to a “safe” position (i.e., lights fail on) upon a loss of communication from the SEPDC or RPDC.
- 2.5.10 Type of Points
- 2.5.10.1 Each controller shall have the following types of points:
- Binary inputs and pulse accumulation;
 - Universal inputs shall be capable of 0-20mA,dry contact, and 0-5VDC,2-10 VDC or 0-10 VDC;
 - Binary outputs to command apparatus of 2 to 3 statuses;
 - Analog inputs to measure real-time variables;
 - Analog outputs (e.g. Current mode 4-20 mA, Voltage mode 0-10VDC, 2-10 VDC) to read and adjust the set-points and positions and for the direct digital control of apparatus.
- 2.5.10.2 The system shall allow the user to change the characteristics of the individual points on each function card. This characterization shall be made possible by means of a keyboard procedure where the user shall transfer specific parameters from the Server that are destined to the RPDC, or from a portable keyboard or one integrated in the RPDC. The user shall be able to modify these parameters from these keyboards.
- 2.5.10.3 If the controller uses multi-point type function cards for control and monitoring, each function card shall have an integrated capacity of auto-control and shall visually indicate its operational status. The failure of a function card in a controller shall not prevent the controller from controlling the other function cards and shall not affect the other controllers.
- 2.5.11 Termination Board
- 2.5.11.1 Each controller shall have a termination board to which the wiring or piping shall be connected. The controller shall be isolated from the command circuits or sensors either by **double voltage relays or optic couplers or** equivalent. All input/output signals shall be terminated on the board using screws or compression spring type terminals. Each analog input shall have the capacity to adapt standard inputs of the industry such as 4 to 20 mill-amperes or 1 to 5 volts DC, or 0 to 10 volts DC without physically modifying the control panel.
- 2.5.11.2 The Contractor shall identify all the wiring connected to the different elements of the system. The numbered auto-adhesive stickers are not acceptable. The Contractor shall use plastic mold (PVC) type reference

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marks, to identify the wiring terminated to the board inside the control panel and at the end device. All wiring shall be identified using full and proper point descriptors.

2.5.12 Telecommunication Interface

2.5.12.1 Communication Network Use

- 2.5.12.1.1 The system shall supervise remote buildings. It shall be possible for the Enterprise Server to communicate with the Supervisory Remote Programmable Digital Controllers (SRPDC) by the ETHERNET communication network furnished by the Owner.

2.5.12.2 Remote Interfaces and Access to Installations on the Owner's Intranet

- 2.5.12.2.1 The communication interfaces such as the ETHERNET, communication cards, computers, and software etc. shall be included with the SRPDC (supervisory panel) for all sites. These interfaces shall be supplied by the Contractor.
- 2.5.12.2.2 The Owner shall provide one (1) network drop and IP address at a given site. EMCS and SRPDC solutions must support LAN-, WAN-, and cellular-connected facility installations based on network availability that will be specified for each location. The Control vendor shall be responsible for coordinating with the Owner's IT department designated personnel.
- 2.5.12.2.3 Each pre-qualified EMCS vendor may be granted Internet access to the Owner's Intranet system through an Owner supplied VPN (or other secure methodology in accordance with COM ITS policies and procedures). This access will be arranged for by the control vendor in coordination with the Owner's designated representative and shall be restricted to a specific duration of time. Each time the vendor accesses the system the date and time and name of person accessing the system shall be recorded and stored within the database. **NO UNAUTHORIZED ACCESS to the Owner's Intranet and EMCS control systems will be permitted.**

2.5.12.3 Communication Modes

- 2.5.12.3.1 The only communication mode to the SRPDC shall be via the owner's ETHERNET network. All necessary accessories to establish communication shall be supplied by the Contractor. Communication modes such as dedicated or dial-up telephone lines or cable modems shall not be accepted.

2.5.13 Communication Protocol

- 2.5.13.1 The system shall be capable of high-speed ETHERNET communication using TCP/IP Protocol through the primary SRPDC (supervisory panel) and the Enterprise Server. The SRPDC at each site shall be assigned an IP address. Communication between SRPDC and RPDC shall be by BACNet IP or MS/TP as specified in the details project specifications.

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2.5.13.2 Where BACNet over IP communication between SRPDC and RPDC is specified, EMCS vendor shall supply a dedicated EMCS Ethernet Managed Switch(es) to manage all sub-network communications between SRPDC and RPDC. All IP and MAC addresses shall be set up by and are the responsibility of the EMCS Vendor. The make/model of the Ethernet Managed Switch shall be discussed with and approved by the Owner.

2.5.14 Computer Interfaces

2.5.14.1 The computer interfaces shall communicate commands and access the SRPDC in each building using the Owner's ETHERNET network via the central Enterprise Server.

2.5.14.2 Communication Interfaces

2.5.14.2.1 The communication interfaces that allow the connection to the computer communication system are those mentioned in sub-section 2.

2.5.14.2.2 Each controller shall have a communication port for connection to the network and also available for a direct connection to an operator interface.

2.5.14.2.3 The operator interface connected to any controller shall allow the operator to interface with each inter-networked controller on the system as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each inter-networked controller.

2.6 SOFTWARE SPECIFICATIONS

2.6.1 General Principles

2.6.1.1 Interface at the EMCS Enterprise Server (SERVER)

2.6.1.1.1 The owner has purchased and installed Tridium Niagara 4 software of the latest revision. This EMCS Enterprise Server Software (ESS) package resides on a dedicated City of Mississauga EMCS Enterprise Server. The owner also maintains a secondary back-up server for the storage of all program files, graphics, trend data, alarms, and reports for the support of connection and monitoring of up to 350 buildings

2.6.1.1.2 The Contractor shall program completely the Owner's EMCS ESS of all described points in the points list of building(s) shown on the plans. The data base shall include the definitions and descriptions (key names) of each point connected to the SRPDC installed in the various buildings.

2.6.1.2 Software Furnished by the Contractor

2.6.1.2.1 The Contractor shall furnish all necessary software and software tools for programming and modification of field panels and for the communication and functional operation of the systems as specified. This software shall be "Open" in nature and licensed to allow for use and modification by the Owner or Owner designated service contractor(s).

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- 2.6.1.2.2 The EMCS ESS shall be installed and operational prior to the delivery of any field based EMCS. The software described in this section of the specifications shall be applicable to all new SRPDC, RPDC, TEC, OEMASC, and as they relate to the new EMCS ESS and Back-up Server.
- 2.6.1.3 Proven Software
 - 2.6.1.3.1 Only proven software shall be accepted.
- 2.6.1.4 Security Requirements
 - 2.6.1.4.1 Only software with the minimum version of an un-deprecated TLS encryption subject to further requirements as specified in Section 250501 paragraph 1.5.10.2 and 1.5.10.3 shall be permitted.
 - 2.6.1.4.2 Software shall utilize Active Directory Log-In and shall come with **False Log-in Protection**
- 2.6.1.5 Type of Points
 - 2.6.1.5.1 The system shall have two (2) types of points: the first type shall derive from a physical measure. A physical point denotes a point physically connected to the system, for example, pressure temperature and relative humidity. These points are defined as “Real”.
 - 2.6.1.5.2 The second type of point is identified as an information point by the operator but is not necessarily a number of a data corresponding to their physical point, for example, a prediction, or a calculation of energy or cost estimates. These points are defined as “Virtual”.
- 2.6.2 Real Time System Management
 - 2.6.2.1 Power Failure and Automatic RE-start
 - 2.6.2.1.1 In case of power failure, the system shall stop in an organized method and a routine procedure shall provide an automatic re-start of the system once the power is restored.
- 2.6.3 Acquisition of Data and Control Software
 - 2.6.3.1 Binary (Digital) Inputs
 - 2.6.3.1.1 The system shall monitor the binary inputs. The actual condition of a two-status device shall continually be saved in memory and represented by a pair of binary statuses. The indications at the SERVER operator and the binary statuses shall be described by the following abbreviations called “Descriptor” such as “OP-CL” for open-closed.
 - 2.6.3.1.2 The system can record the number of changes of state of a binary input in order to measure the variables such as flow indicated by pulses.
 - 2.6.3.1.3 Minimum requirements are to comply with the BAC-net standard for data sharing. The user must be able to specify either input condition for alarming. This Binary Input must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an “on” condition. The user must be able to specify either input condition as the “on” condition.
 - 2.6.3.2 Analog Inputs

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- 2.6.3.2.1 Minimum requirements are to comply with the BAC-net standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
- 2.6.3.2.2 The system shall read, convert, transmit and display the analog values of all the required points.
- 2.6.3.2.3 All displays and readings shall display analog point's value in a numerical form with appropriate units and the negative sign if necessary. The displayed values shall contain the necessary number of figures plus a decimal point if required.
- 2.6.3.2.4 The Owner shall define the units of measure to describe the changes of state and the information requests. Examples of units of measure: KPA for kilo Pascal, °C for degree Celsius.
- 2.6.3.2.5 The system shall be capable of using the English system of measure as well as the International system without modifying the equipment. The Owner may define up to 50 analog ranges. Each range may define as linear, square root extract or whatever functions dependent on the results of a calculation.
- 2.6.3.2.6 The operator may assign specific limits to each analog point (2 high and 2 low). The system shall compare the analog readings with the predetermined limits and shall advise the operator every time a point goes into alarm or returns to normal conditions.
- 2.6.3.2.7 A simple differential shall be associated to every specific limit. This differential shall precisely determine the gap necessary for a return to normal indication when a point returns within its normal operation range.
- 2.6.3.2.8 The user shall enter all the limits and the entire differential directly with the same units of the measured variables. The system shall react on an analog point update when an analog point passes from a normal condition to a high or a low limit condition as well as a return to the normal condition, when stopping or starting the equipment, when displaying a graphic or message, when printing a report or a message, or when readjusting the setpoint of a controller according to the established interlock sequence.
- 2.6.3.2.9 The Owner shall be able to create a summary of the analog limits and differentials with the high and low limits and differentials for all the specified analog points.
- 2.6.3.3 Binary (Digital) Outputs
 - 2.6.3.3.1 Minimum requirements are to comply with the BAC-net standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as inter-start delay must be provided.
 - 2.6.3.3.2 The system shall control local devices having 2 or 3 statuses. The operator shall be able to control the local devices. Descriptors defining the commands that the operator wishes to execute shall be used.

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- 2.6.3.3.3 The commands shall be grouped, and one command is given per status. Each binary output shall be programmed to respond to only one group of commands. These command groups shall be for example: OP-AUTO-CL for Open-Auto-Closed or STR-STO for Start-Stop.
- 2.6.3.3.4 The operator shall be able to issue global commands including but not limited to:
- Time of day scheduling
 - Weekly schedules
 - Event/Holiday Schedules
 - A positive feedback response shall be used for all the command points to make sure that the monitored device, motor, controller, etc. has in fact received and executed the command issued by the operator or the system.
 - All commands not executed as requested, shall emit a message to the operator.
- 2.6.3.4 Analog Outputs
- 2.6.3.4.1 Minimum requirements are to comply with the BAC-net standard for data sharing.
- 2.6.3.4.2 The remote reset of controller setpoints and/or valves shall be possible for all the specified reset points. The reset values shall use units that correspond to the controlled variable such as degrees Fahrenheit, degrees Celsius, kilo Pascal's, etc.
- 2.6.3.4.3 The operator data entries shall be the same as the output data of the reset points. For example, to change a pressure controller setpoint from 10 KPA to 110KPA, the operator shall simply enter the reset value of 110KPA.
- 2.6.3.4.4 A power supply failure at the existing SERVER or at the local SRPDC shall not affect the setpoints. These setpoints shall maintain the last ordered value.
- 2.6.3.4.5 The operator shall be able to issue global zone temperature setup including occupied/unoccupied mode temperature set points.
- 2.6.3.5 Change of State
- 2.6.3.5.1 The system shall detect all changes of state of a point as specified hereafter and shall report these changes of state to the operator. Any change of state specified as such shall set off an audible alarm. Acknowledgement shall cancel the audible alarm.
- 2.6.3.5.2 Any change of state of a point shall include a descriptor, identification, data units, date and hour. The printout of a binary monitor point shall include binary status identification, indications relative to an abnormal condition or an alarm point condition, an indication that the point equipment is out of service, the date and the hour.

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- 2.6.3.5.3 For an analog change of state, the system shall print the point identification, its analog value with its units, an indication identifying whether the value is high or low, the date and the hour.
- 2.6.3.5.4 For each alarm point, the system shall print a message, custom predefined by the User, which shall be printed immediately following the point display.
- 2.6.3.5.5 The system shall communicate the information of a change of state of a point towards a particular desk. The reception of the change of state shall not be interrupted by the display summary asked by the operator.
- 2.6.3.5.6 The display of the changes of state on the colour screen shall be done in priority as defined by the User. In addition, the User shall decide the change of colour related to the acquisition of the change of state.
- 2.6.3.5.7 Upon receiving changes of state, they shall be printed in chronological order. The print outs of acquisitions of change of states shall be done simultaneously as the acquisition itself.
- 2.6.3.5.8 The system shall report the multiple changes of state according to the established priority levels when generating the database. The Owner shall decide if a change of state necessitates an acknowledgement.
- 2.6.3.6 Access Control
 - 2.6.3.6.1 Provide a minimum of 5 (Server) and 3 (SRPDC) levels of command security. **Individual operators shall be able to be assigned to security level.** Assignment to a security level shall allow the operator to use commands that have been assigned to that level of security or below only. It shall be possible to re-assign security levels to operators, and commands online, through an operator's terminal (by the owner's system manager). The City of Mississauga will be defining Access Levels as part of the individual projects.
 - 2.6.3.6.2 Access to SRPDC shall be Restricted to Owner's administrator, EMCS Vendor and one (1) additional Owner assigned user. All other access to EMCS shall be routed through the Enterprise Server.
 - 2.6.3.6.3 As outlined in part 2.6.1.4.2, operators shall log-in using Active Directory and the system shall prohibit False Login. A log of the time and date of each log-on/log-off (both a regular log-off and an accidental log-off by closing the browser) and activity of users shall be recorded on the server and accessible for print off by the Owner's system manager.
 - 2.6.3.6.4 Multiple operators shall be able to be logged on different terminals, under different security levels, simultaneously. The fact that multiple operators are signed on concurrently shall be transparent to the individual operators. A minimum of 25 users/operators shall be able to access the system concurrently.
- 2.6.3.7 Reports Logs & Records
 - 2.6.3.7.1 Provide a reporting package that allows operators with properly designated user access level(s) to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date.

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Provide the ability for the operator to obtain real-time logs of all objects by type or status (i.e. alarms, lockout, normal). Reports and logs shall be stored on the central enterprise server memory in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.

2.6.3.7.2 The report generator shall include time, day, month, year, report title, operator's initials, and shall produce as a minimum the following reports:

- All points in allocation
- All points of a point type
- All points in an individual system
- All points (SRPDC, RPDC, & TEC)
- Acronym summary
- Alarm summary
- Alarm Messages
- Lockout summary
- Disable "Locked-out" points summary: including point name, whether disable by system or by operator.
- Override summary
- Generate and format reports for graphical and numerical display from real time and store data.
- Print and store reports as selected by the operator.
- Summary of sensor spans and bases
- Summary of analog alarm limits and differentials
- Summary of point parameters
- Summary of RPDC loop parameters
- Run time summary: summary of accumulated time of selected equipment. Include point name, run, and time to date, alarm limit setting. Run time to accumulate until reset individually by the operator.
- Trend logs
- Historical profiles

2.6.3.7.3 Point Identifiers

2.6.3.7.3.1 The EMCS shall locate a point to be monitored or controlled with unique point identifier.

2.6.3.7.3.2 The EMCS shall be able to identify group's points in at least the following manners:

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- 2.6.3.7.3.2.1 Points that are geographically in, for example, a penthouse, or building.
- 2.6.3.7.3.2.2 Points that are part of a closed system, for example, a fan system or a water system.
- 2.6.3.7.3.2.3 Points that perform similar functions, for example, all fans supply air temperatures or leaving chilled water temperatures.
- 2.6.3.7.4 Alarm Reports & Records
 - 2.6.3.7.4.1 The alarm summary shall include the time and date of occurrence, the operator's username who acknowledge the alarm, the location, system and point descriptor, value or status at the time of alarm and alarm condition(i.e. high, low, return to normal etc.) The recording of alarms on specific points shall be able to be enabled or disabled on command. A summary of points disable for alarm recording shall be provided.
- 2.6.3.7.5 Alarm Scan
 - 2.6.3.7.5.1 The EMCS system shall continuously scan all points connected to it and update the data base on binary changes of state and significance of analog changes. The system shall compare any change of state or analog update to establish parameters and determine if the point is in an alarm condition.
 - 2.6.3.7.5.2 Alarms shall be queued for reporting and under NO circumstances shall any alarm go undetected due multiple alarms.
- 2.6.3.7.6 Alarm Messages
 - 2.6.3.7.6.1 Provide capability to create and assign to any point a message to be printed or to be sent to a pager or other handheld device such as a smart phone, tablet, etc. at the time of alarm. Summaries of message content and points assigned to messages shall be displayed on the operator's terminal or printed on the assigned device on command.
- 2.6.3.7.7 Alarm Acknowledgement
 - 2.6.3.7.7.1 Provide capability to display alarms on the operator's terminal and update these alarms once a minute. Alarms shall be acknowledged when displayed by prompting for operator's username. The operator's username shall be recorded with the alarm.
- 2.6.3.7.8 Alarm Management
 - 2.6.3.7.8.1 Establish and provide alarm management programming using the server software and provide

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any additional software as necessary to accomplish the following:

- **Critical Alarms** – Critical alarms are defined as those that require the immediate attention and action of Facility Operations. Examples – VSD Failure, low & high water temperature, over/under pressure, loss of outside air sensor, loss of power, computer room cooling high temperature, etc.
- These alarms shall provide both indication at the operator workstations through the EMCS server and shall be sent to nominated Building and/or Security Services Department staff (or other locations as defined by the owner) for immediate action. Alarms shall be sent via SMS and/or Email etc. indicating the Building ID, Alarm Indication and Alarm Parameter, Time of Alarm, etc.
- All alarm settings shall be super user adjustable through the Alarm Settings graphic page.
- Critical alarms indication on the graphics shall appear as a Flashing Red background with the Word ALARM (under Alarm condition) and Green Background with the Work Normal when not in alarm.
- Critical Alarms shall also be recorded and stored on the EMCS Server
- **Environmental Alarms** – Environmental Alarms are defined as Non-Critical (HVAC related) alarms and as indicated on site specific points list and sequences. Environmental alarms typically include but are not limited to the following:
 - Temperature/humidity out of specified range etc.
 - Mixed air low limit
 - Command vs Status
- Environmental alarms shall provide indication on the graphics (Flashing Yellow) both the EMCS ESS operator workstation(s) and workstations connected through the SRPDC and shall remain until the alarm condition is corrected.

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- **Maintenance Alarms** – Maintenance alarms as defined as important operational alarms that require the attention and action of Maintenance personnel and as indicated on the site-specific points list and sequences.
- Examples include equipment run-times, pressure drop across filters, etc. These alarms shall be generated by the EMCS and stored in a database at the central EMCS server until acknowledged or removed by system operations. They shall also send out an Email indicating building, required maintenance, etc.
- **Utility Alarms** – Example – Peak Demand Exceeded, daily consumption exceeded. These alarm limits shall be set-up and established during commissioning. The alarms shall provide indication both at the operator workstation and shall send out an email to various email accounts indicating that anticipated parameters have been exceeded.
- All alarms shall be stored in a database under various file headings (i.e. critical, environmental, maintenance, energy), date and time stamped including the date of acknowledgement of the alarm parameter, until cleared by the system administrator.
- Alarms shall be set-up to be functional during the appropriate seasons and inactive when outside of the related season (i.e. – low water temperature alarms shall not be active during summer, chilled water alarms shall not be active after the central chilled water has been shut off to the building).

2.6.3.7.9 Scheduled Events/Modes

- 2.6.3.7.9.1 Any command point in the system shall be able to be assigned to a time of day and calendar operating schedule as well as temporary overrides, programmed events (though 3rd party database application), and temperature based operating parameters through any operator's terminal (based on assigned user authority level).
- 2.6.3.7.9.2 The number of starts and stops per point, per day, shall not be limited. Points shall be assigned "time windows" in which they shall either be ON or OFF during the time of the window. Points shall be able to

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		be assigned different time windows each day of the week plus holiday schedule.
	2.6.3.7.9.3	The operator shall be able to list summaries of the time schedules on the operator's terminal. The summary shall indicate the point and the various time windows assigned for that particular day. The summary shall be able to be restricted to a particular location, system or point as well as those days of the week desired.
	2.6.3.7.9.4	The system shall be capable of and set-up by the Vendor to access other 3 rd party database programs to obtain data necessary for the scheduling of "EVENTS" that occur outside of the established Occupied Schedules. (Ex: Community Use Programming).
2.6.3.7.10	Overrides	
	2.6.3.7.10.1	Owner's designated administrator shall be able to override all point types, schedules, etc. until releasing from Manual to Auto.
	2.6.3.7.10.2	Operators with specified security access level(s) shall be able to override analogue and digital output points with a Timed Override period not to exceed 24 hours. When timed override expires, the system shall revert to "Auto" mode.
	2.6.3.7.10.3	The EMCS shall keep track of all override activities and store information on Enterprise Server indicating the Date/Time of override and Username who initiated.
	2.6.3.7.10.4	When any point or schedule is overridden, the Graphical User Interface shall display a distinctive color indicating the system is not in Auto Mode and shall return to normal display once the override is removed.
2.6.3.7.11	Trending	
	2.6.3.7.11.1	The EMCS trending shall be set-up by the EMCS Vendor during each installation and shall store data at the SRPDC and then be automatically uploaded to the EMCS ESS. This shall include all inputs/outputs points.
	2.6.3.7.11.2	The SRPDC shall communicate (upload) trend data to the ESS at regular intervals for long term storage and shall be capable of storing all site Trend Data for a minimum period of one (1) months without manual data handling.

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- 2.6.3.7.11.3 As a minimum, provide capacity for set up of up to 150 trend logs per SRPDC at one time. Storage duration and data capture intervals shall be user adjustable. Provide data for review in both graphical and tabular format accessible through the EMCS server on operator workstations.
- 2.6.3.8 Auto-Diagnostic Message
- 2.6.3.8.1 The system shall continuously query itself to detect any failure or malfunction of the circuits and shall be able to report to the operator any change of state of any equipment. The diagnostic shall include at least the following messages:
- The system can/cannot communicate with a point.
 - The system can/cannot communicate with the SRPDC & other RPDC.
 - The system can/cannot communicate with an operator terminal.
 - The SRPDC & other RPDC are operational/non-operational.
 - A power failure was detected on such a day, and such an hour.
- 2.6.3.8.2 Summaries and readings, when used, shall indicate with special indications or references the state of the communication material of each point. These indicators shall be continuously updated.
- 2.6.3.9 Locking
- 2.6.3.9.1 There are two modes of locking. When the Owner locks the change of state report of a point, this point shall execute all addressed commands but shall not report its change of state as a normal or abnormal condition.
- 2.6.3.9.2 When the Owner locks the capacity of executing a command of a point, the point shall report all changes of its state without executing any addressed command except the unlock command.
- 2.6.3.9.3 In addition, the Owner can lock a point simultaneously in the two modes. The execution of the locking command shall clear all inhibition of change of state or command.
- 2.6.3.9.4 Upon the Owner's demand, the system shall supply a summary of locking showing the locked points and their mode of locking.
- 2.6.3.9.5 All requested reports and summaries shall display a locking indication for the locked points.
- 2.6.3.9.6 Reports and summaries shall indicate the locking/unlocking status of each point by means of special indications or reference marks.
- 2.6.3.10 Interlocks

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- 2.6.3.10.1 The User may define the interlock sequences that connect two or more points. The User may assign different priorities for the interlock sequences in such a manner that a point used in multiple sequences shall respond to those of a higher level.
- 2.6.3.11 Totalization
- 2.6.3.11.1 This program shall allow totalizing of all binary or analog points.
- 2.6.3.11.2 The User may:
- Determine the state of an open-closed, normal-abnormal point that must be totalized.
 - Designate the basic totalization units and the consumption units.
 - Interrupt and resume the totalization of a point as required.
 - Modify the total value of the day or the current period and define a warning limit. When the total exceeds the warning limit, it shall produce a change of state and the count shall be reset to zero. When the total exceeds the maximum physical limit of the computer, it shall produce another change of state and the count shall be reset to zero.
- 2.6.3.11.3 The Totalization Summary shall include:
- Point identification
 - Appropriate indication
 - Last sample value
 - State of the totalization program: active or non-active
 - Totalization basic units
 - Totalization parameters
 - Totalled value of the day with appropriate units of measure
 - Total value for the current period with appropriate units of measure
 - Total value for the last period
 - Warning limit
 - Reset to zero limit
 - Associated optimal point to stop totalization
- 2.6.3.11.4 The summary of a point or a group of points may be requested as described by the User.
- 2.6.3.12 Precision
- 2.6.3.12.1 The system shall have a minimum precision of input to the SRPDC to the display or print out of + /- 0.5% of the displayed or printed value.
- 2.6.3.13 Point Segregation

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- 2.6.3.13.1 The User may define segregation of the points as a function of his needs. For example, the points in a building or in a region may be referred to a specific terminal during the day, and for the evening or at night they may be referred automatically to another terminal without any operator intervention. Also, a point in one RPDC may be referred to one or many different terminals independently from the other points in the same RPDC.
- 2.6.3.14 SERVER-SRPDC & SRPDC-SERVER (Server) Communication
 - 2.6.3.14.1 Every building shall have a stand-alone program and installation that shall render it independent from the SERVER and the other buildings. The data transfer between the SRPDC of the same building shall not be done through the SERVER when this data is necessary for a control sequence.
- 2.6.3.15 Remote Control
 - 2.6.3.15.1 Remote control shall allow the verification of all digital, analog and calculated points. Setpoints may be changed and the position of the controlled devices may be fixed. All analog and calculated points, function of controlled elements and the status of the digital points may be displayed.
 - 2.6.3.15.2 The SERVER may also simulate the operation of a terminal to be connected to a SRPDC. This terminal mode shall permit communication to the SRPDC in real time to change setpoints, schedules, take temperature readings and reprogram the SRPDC. All modifications shall be automatically updated on the hard disc.
- 2.6.3.16 Project Management
 - 2.6.3.16.1 At the beginning of the project, the Contractor shall present to the Owner all the documentations and required forms for point definition and for programming.
 - 2.6.3.16.2 All associated details regarding the segregation, the penetration and the communication of each point shall be established and communicated at the beginning of the project.
- 2.6.4 Owner's Programming Capacities
 - 2.6.4.1 Programming Definition
 - 2.6.4.1.1 The system shall be programmable at two levels.
 - 2.6.4.1.1.1 The first level is the programming in the conversational English language. This kind of programming is used by the Owner to create his own graphs, his own displays and messages, etc. as explained in the following paragraphs.
 - 2.6.4.1.1.2 The second level shall allow to modify the software furnished by the supplier and shall be used for example to add new symbols in the library of software to create graphics.
 - 2.6.4.2 GUI Creation and Modification

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- 2.6.4.2.1 Creation and Modification to the Database
- 2.6.4.2.1.1 By using the first level programming, the Owner may affect all the changes to the database with the system on-line and operational.
- 2.6.4.2.1.2 The Owner may at the very least do the following operations:
- Add and delete points
 - Modify all point parameters
 - Change, add, and delete point descriptions
 - Change, add, and delete units
 - Change, add, and delete points in various programs
 - Choose the analog alarm limits and their differentials
 - Define each function card or module to accept the different analog inputs or the different binary inputs
 - Create custom links between points
 - Write the program of the SRPDC & RPDC from the SERVER. Load this program in the SRPDC & RPDC while maintaining the capacity to receive alarms and coloured graphics.
 - Modify the penetration menu
 - Modify the point segregation
 - Modify the communication parameters and the input/output ports
- 2.6.4.2.2 The owner shall be able to modify all points in the database. This modification shall include the addition, elimination and modification of the unit scales or operation modes. The addition of a new point on site shall be accomplished completed by the means of a keyboard once all the material is installed in its place.
- 2.6.4.2.3 Once the function cards or module of the SRPDC & RPDC are modified, a change of function can be executed consequently by entering a keyboard command. For example, an analog input point which is presently used by a temperature sensor can be modified to operate with a pressure sensor.
- 2.6.4.2.4 When new points are to be added on site, they may either be grouped in a new display system or may be substituted by existing points in the existing system or may simply be added to the existing systems.
- 2.6.4.3 Custom Made Equations and Links between Points
- 2.6.4.3.1 The system shall allow the Owner to develop custom made sequences of operation, unique control algorithms and interactive links between

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- the points, custom made calculations, etc. This program shall directly use the dynamic data of the system.
- 2.6.4.3.2 The system shall at the very least perform the following operations:
- Addition/subtraction
 - Multiplication/division
 - Square root/exponential
 - Linear equations/quadratic equations
- 2.6.4.3.3 And can execute the following programming instructions:
- And/or
 - Equal/unequal to
 - Less than/more than
- 2.6.4.3.4 All connected points to the system such as temperature, pressure, flow, status, alarm points etc. shall be used in real time in these equations. Also, the Inputs shall include the real time, day of the week, date, constants, and results of other calculations.
- 2.6.4.3.5 As an equation result of any combination of mathematical or logical function of dynamic data of the system, the system shall, as a minimum, perform the following changes:
- Start-stop command or open/close
 - Increase/decrease setpoints in the system
 - Initiate reports and displays
 - Activate the application programs
 - Start/stop alarm functions
 - Change the analog output for direct digital control
- 2.6.4.3.6 The Owner's entries for equation processing shall be made with a keyboard command using the first level programming. A step-by-step interactive routine shall be furnished to guide the User's entries. Systems that demand binary input, decimals, machine languages or digital codes shall not be accepted.
- 2.6.4.3.7 The computer shall be able, by using equations, to make all calculations and operations, as follows:
- Flows
 - Predictions
 - Comparison of forecasts and historical data
 - Display or printout of a message or a graphic
 - When an analog point in the system exceeds a certain limit, change of setpoint of a controller

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- Display of instructions for actions to be taken by the operator when the value exceeds a certain limit
 - Degree-days for heating and cooling
- 2.6.4.4 New Programming
- 2.6.4.4.1 The Owner, by using the second level language, may program the system to support all the following programs for the development, the compilation, the loading and the execution by the Owner.
- 2.6.4.5 Copy of the Software
- 2.6.4.5.1 The Contractor shall give the Owner a copy of the block diagram of programming logic included with 'As-Built'.
- 2.6.4.5.2 The Contractor shall furnish to the Owner any software/hardware and software tools necessary to edit, modify, add or delete a point from the system and the graphics. This applied to the Enterprise Server, SRPDC and RPDC.
- 2.6.4.6 Software and SRPDC, RPDC Programming
- 2.6.4.6.1 The SRPDC & RPDC shall have its own BAC-net standard software that shall allow it to function totally independent from the SERVER. In addition to the standard software already included in the existing SERVER, the SRPDC & associated RPDC controls shall have its own energy management software that includes but is not limited to the following software:
- Start/stop time schedule (weekly, holidays and alternative)
 - Run-time
 - Load shedding
 - Duty cycling
 - Run-time optimization
 - Outdoor air quality optimization
 - Inter-lock
 - PID Control Loop (Each individual property must be adjustable as well as able to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control).
 - Chiller and boiler optimization
 - Optimization of water temperature or air supply
 - Power failure/auto restart feature (when power is restarted the RPDC & RPDC controls shall automatically restart in an orderly fashion including all appropriate delay without the necessity for operator intervention)
 - Point summary reports, alarms summary reports, trending

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2.6.4.6.2 Load reset control; parameters shall include the following:

- Analog limits for heating and/or cooling as appropriate.
- Analog differential limits.
- Magnitude of set point increment.
- Program frequency.
- Communication between SRPDC and SERVER through a dedicated communication network or LAN/WEB technologies and network service providers.
- Communication between SRPDC and RPDC through a local bus communication line.

Part 3 Execution

3.1 LOCATION

- 3.1.1 Location of SRPDC and RPDC to be in dedicated mechanical/electrical rooms or as approved by Consultant and/or Owner.
- 3.1.2 Location of TEC shall be dictated by the placement of terminal equipment to be controlled (i.e. VAV Box, Heat Pump, etc.). Except where otherwise noted, TEC shall be located in a NEMA 1 enclosure within five (5) feet of terminal equipment being controlled and shall have liquid Tight flexible conduit between the Controller enclosure and Terminal equipment neatly installed and secure to structure (as close as possible to point of final termination).
- 3.1.3 Any controllers, control devices, sensors, etc. located in public space shall not have an accessible communication port for connecting to the controller/device and accessing the EMCS. If a communication port is present, the controller/device must be enclosed in a lockable cabinet prohibiting access to the communication port by un-authorized personnel.

3.2 HARDWARE INSTALLATION

- 3.2.1 Install Controllers in secure locking enclosures or as directed by Engineer/Consultant.
- 3.2.2 Terminal Equipment controllers above ceiling system may be unit mounted (i.e. VAV, Heat pumps, etc.).
- 3.2.3 Provide necessary power from local 120V branch circuit panel for equipment.
- 3.2.4 Install tamper locks on breakers of circuit breaker panel.
- 3.2.5 Use uninterruptible Power Supply (UPS) and emergency power when equipment must operate in emergency and co-ordinating mode.

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3.3 SOFTWARE/PROGRAMMING INSTALLATION

- 3.3.1 Software shall be installed, and system programmed and run-tested prior to installation on site. Any adjustments and/or changes to programming as identified during the commissioning process shall be implemented by the contractor at no additional cost to the project and then re-tested with Commissioning Agent. Further adjustments may also be identified during seasonal commissioning process and shall be carried out by the contractor at no additional charge.
- 3.3.2 Custom site-specific graphics shall be generated using City of Mississauga (CoM) template workstations as guideline. Preliminary, site specific graphics shall be created and delivered to CoM (and Consultant) for review and comment, followed by multiple rounds of modification before final approval (and prior to uploading to site). Contractor shall make all necessary changes and updates as identified during shop drawing phase and again during commissioning phase. Final sequences and As-Built Documentation shall be updated each time there is a change and shall be included for both manual and PDF links through graphical Interface.
- 3.3.3 The system programmer shall be present during the commissioning process to ensure continuity throughout the project.
- 3.3.4 All changes shall be uploaded to Enterprise Server immediately prior to leaving the site.

END OF SECTION 25 30 01

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EMCS: FIELD CONTROL DEVICES

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 Control devices integral to the Building Energy Monitoring and Control System (EMCS):
 - .1 Transmitters, sensors, controls, meters, switches, transducers, dampers, damper operators, valves, valve actuators, and low voltage current transformers.
- .2 Related Sections:
 - .1 Section 07 84 00 – Fire stopping.
 - .2 Section 25 01 11 - EMCS: Start-Up, Verification and Commissioning.
 - .3 Section 25 05 01 - EMCS: General Requirements.
 - .4 Section 25 05 02 - EMCS: Submittal and Review Process
 - .5 Section 25 05 54 - EMCS: Identification.
- .3 REFERENCES
 - .1 American National Standards Institute (ANSI).
 - .1 ANSI C12.7-1993 (R1999), Requirements for Watthour Meter Sockets.
 - .2 ANSI/IEEE C57.13-1993, Standard Requirements for Instrument Transformers.
 - .2 American Society for Testing and Materials International, (ASTM).
 - .1 ASTM B148-97(03), Standard Specification for Aluminum-Bronze Sand Castings.
 - .3 National Electrical Manufacturer's Association (NEMA).
 - .1 NEMA 250-03, Enclosures for Electrical Equipment (1000 Volts Maximum).
 - .4 Air Movement and Control Association, Inc. (AMCA).
 - .1 AMCA Standard 500-D-98, Laboratory Method of Testing Dampers for Rating.
 - .5 Canadian Standards Association (CSA International).
 - .1 CSA-C22.1-02, Canadian Electrical Code, Part 1 (19th Edition), Safety Standard for Electrical Installations.
 - .6 City of Mississauga Communication Cabling Specification Standard

1.2 DEFINITIONS

- .1 Acronyms and Definitions: refer to Section 25 05 01 - General Requirements.

1.3 SUBMITTALS

- .1 Submit shop drawings and manufacturer's installation instructions in accordance with Section 25 05 02 - EMCS: Submittals and Review Process.
- .2 Pre-Installation Tests.

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- .1 Submit samples at random from equipment shipped, as requested by Consultant/Engineer, for testing before installation. Replace devices not meeting specified performance and accuracy.
- .3 Manufacturer's Instructions:
 - .1 Submit manufacturer's installation instructions for specified equipment and devices.

1.4 EXISTING CONDITIONS

- .1 Cutting and Patching: in accordance with Specifications supplemented as specified herein.
- .2 Repair surfaces damaged during execution of Work.
- .3 One (1) week after project kick-off meeting, Owner to review and identify any materials designated to be turned over for re-use (after removal by EMCS contractor). EMCS contractor shall dispose of all other redundant materials in an environmentally friendly manner.

Part 2 Products

2.1 GENERAL

- .1 Control devices of each category to be of same type and manufacturer.
- .2 External trim materials to be corrosion resistant. Internal parts to be assembled in watertight, shockproof, vibration-proof, assembly.
- .3 Operating conditions: 0 - 32°C with 10 - 90% RH (non-condensing) unless otherwise specified.
- .4 Terminations: use standard conduit box with slot screwdriver compression connector block unless otherwise specified.
- .5 Transmitters and sensors to be unaffected by external transmitters including walkie talkies.
- .6 Account for hysteresis, relaxation time, maximum and minimum limits in applications of sensors and controls.
- .7 Outdoor installations: use weatherproof construction in NEMA 4 enclosures.
- .8 Devices installed in user occupied space not to exceed Noise Criteria (NC) of 35. Noise generated by any device must not be detectable above space ambient conditions.
- .9 Range: including temperature, humidity, pressure, as indicated in project specific I/O summary (Points List).

2.2 TEMPERATURE SENSOR

- .1 Temperature sensors (PT100 or 1000 ohm) shall be "RTD" platinum element 100 or 1000 ohm at 0 degrees C (plus or minus 0.2 ohms), thin film type or equivalent, having accuracies as follows:
 - Coefficient of resistivity: (0.00385) ohms/ohm °C.

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- Accuracy 0.2°C over range of 0 to 70°C.
 - Stability 0.02°C drift per year.
- .2 Sensors shall have a time constant response of less than four (4) seconds to a temperature change of 10°C. Thermistors are not accepted.
 - .3 Sensors shall be manually calibrated on site so that the wiring length does not detract from the sensor accuracy specified.
 - .4 Temperature sensors shall be of the following types:
 - .1 Room sensor- suitable for all walls mounting, with metal protective guard. Element length of 0.4" to 2" (10 – 50mm) with ceramic tube protection or equivalent.
 - .2 General purpose duct sensor, suitable for insertion into air ducts. Element length of 18" (457 mm) or 30" (760 mm), junction box wiring connections and gasket to prevent air leakage or vibration noise.
 - .3 Averaging sensor duct type, continuous filament with immersion length of 18' (5486 mm) minimum, junction box wiring connections and gasket to prevent air leakage or vibration noise. For duct greater in any dimension than 48 inches (1219mm) and or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used. Capillary supports at the sides of the duct shall be provided to support the sensing string.
 - .4 Outside air sensor shall consist of a single device sensor, ventilated non- metallic sun shield designed to minimize solar and wind effect, utility box terminations, and watertight gasket to prevent water seepage.
 - .5 High Limit sensor shall be manual reset type. Sensing element shall be bimetal
 - .6 Terminal Unit space temperature sensors shall be provided in accordance with the drawing at the locations indicated with the following options:
 - Standard Wall-mount Space sensor
 - Set-point Adjustment Buttons ("+" & "-")
 - Override/Bypass
 - Occupancy
 - RH
 - NO Network Jack
 - .5 Thermostats shall provide flexibility to adjust the following Parameters:
 - .1 Adjustable Temporary Occupancy Over-ride (from 0 to 24 hours)
 - .2 Adjustable heating, cooling dead-band from 2°C to 4°C
 - .3 Adjustable set-point limits (i.e. +/- 2°C)
 - .6 In all public areas as such as Arenas, Cafeterias, Hallways and corridors where additional security is required the sensor shall be a blank stainless steel wall plate temperature sensor equal to Greystone type model #TE200AS (PT 1000-1000 Ohms, Platinum)
 - .7 The Network Thermostat shall employ non-volatile electrical erasable programmable read-only memory (EEPROM) for all adjustable parameters.

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2.3 TEMPERATURE TRANSMITTERS

- .1 Temperature Transmitters (PT 100 or 1000 ohm) at 0° C shall be a platinum resistance detector type of sensors.
- .2 The Power supply shall be 24 VDC with effect less than 0.01°C per volt change.
- .3 The output signal: 4-20 mA into (500) ohm maximum load. Combined non-linearity, repeatability, hysteresis effects: not to exceed plus or minus 0.5% of full-scale output.
- .4 The maximum current to (100 or 1000 ohm) RTD sensor not to exceed 25 mA. Temperature effects: not to exceed plus or minus 1.0% of full scale 50°C.
- .5 Transmitter ranges: Select narrowest range to suit application from the following:
 - - 50°C to + 50°C, plus or minus 0.5°degrees C
 - - 0°C to + 50°C, plus or minus 0.25°degrees C
 - - 0°C to + 25°C, plus or minus 0.1° degrees C
 - -10°C to + 35°C, plus or minus 0.25° degrees C

2.4 LOW LIMIT CONTROLS (FREEZE STAT)

- .1 Provide one (1) Low Limit sensor for each 20 sq. ft. (1.86 sq. m) of coil face. Low limit thermostats shall be of the vapor pressure remote element, manual reset type with adjustable set point. The device shall respond to the lowest temperature to which 1 foot of the element is exposed.
- .2 Capillary sensing tubing serpentine vertically across the air flow entering the face of the coil and be supported firmly by mechanical clips.
- .3 The Low Limit sensor shall be DPDT with a minimum of (1) NO contact and one (1) NC contact. One set of contacts shall be wired directly to controlled mechanical equipment contactor/VSD in order to affect both automatic and manual (HOA) switch positions. The second set of contacts will be wired to a digital input for annunciation of freeze protection alarm condition. Manual reset type is required.

2.5 HIGH LIMIT CONTROLS

- .1 Provide High Limit Controls where indicated. Connect thermostat controllers that are capable of stopping fans in event of excessive temperatures in fan circuits. Provide thermostats with fixed or adjustable settings to operate at not less than 32°C above normal maximum temperature at their location in the air handling system.
- .2 The High Limit sensor shall be DPDT with a minimum of (1) NO contact and one (1) NC contact. One set of contacts shall be wired directly to controlled mechanical equipment contactor/VSD in order to affect both automatic and manual (HOA) switch positions. The second set of contacts will be wired to a digital input for annunciation of high limit alarm condition. Manual reset type is required.

2.6 IMMERSION WELLS

- .1 Immersion wells shall be stainless steel or may be copper only if the medium being controlled is treated with appropriate chemicals products that inhibit corrosion and heat transfer compound to be compatible with sensors.

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- .2 Contractor shall be responsible for filling wells with suitable fluid for proper thermal conductivity transmittance.

2.7 RELATIVE HUMIDITY SENSORS/TRANSMITTERS

- .1 Relative humidity transmitters and/or sensors shall have electronic circuits to compensate for element variations. The sensors shall have an operating range of 5 to 90% RH minimum, with a (\pm) 5% RH accuracy.
- .2 Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with neoprene grommet, bushing, and a mounting bracket.
- .3 Transmitters shall be shipped factory pre-calibrated.
- .4 Outdoor Humidity sensor requirements:
 - Range 0-100% RH minimum
 - Operating temperature range: -40 to 50°C
 - Absolute accuracy: plus or minus 2%
 - Temperature coefficient: plus or minus 0.03% RH/°C over 0 to 50 degrees.
 - Must be unaffected by condensation or 100% saturation.
 - No routine maintenance or calibration is required.
- .5 The humidity station shall be suitable for duct or outside mounting and consist of sensors, ventilated non-metallic sun shield, utility box for terminations, and watertight gasket to prevent water seepage.
- .6 The Humidity transmitters shall have the following requirements:
 - Output signal of 4-20 mA into (500) ohm maximum load. or equivalent.
 - Output variations: not to exceed 0.2% of full-scale output for supply voltage variations of plus or minus 10%.
 - Output linearity error: plus or minus 1.0% maximum of full scale output.
 - Shall have output short circuit and open circuit protection.
 - Integral zero and span adjustments.

2.8 CO2 SENSORS

- .1 CO2 sensors shall be a photo –acoustic type CO2 sensor with integral transducers and linear output. The devices shall read CO2 concentrations between 0 and 2000 ppm with full scale accuracy of at least plus or minus 100 ppm. The sensor shall have multiple outputs (0 -10 VDC or 4- 20 ma), annual zero drift + /- 10 ppm and automatic self-diagnostics.

2.9 AIR QUALITY SENSORS

- .1 The Air Quality sensor shall monitor a wide range of gaseous volatile organic component common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor shall automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have service rating of 0 to 80°C or 32 to 140°F and 5 to 95% relative humidity.

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2.10 STATIC PRESSURE TRANSMITTERS

- .1 Static pressure transmitters shall have a multipoint sensing element with self-averaging manifold.
- .2 Requirements:
 - Maximum pressure loss shall be 0.75" w.g. at 2000 CFM with an accuracy of 1% of total duct static.
 - Output signal of 4-20 mA into 500-ohm maximum load or equivalent.
 - Accuracy: 0.4% of span
 - Repeatability: within .5% of output
 - Linearity: within 1.5% of output
 - Dead-band or hysteresis: 0.1% of span
 - Output short circuit protection.
 - Calibrated span: not to exceed 150% of duct static pressure at maximum flow
 - Pressure +/- 2% of the transmitter span.

2.11 FLOW (AIR FLOW & WATER)

- .1 Electronic Air Flow Monitoring System shall be solid state electronic device comprised of a thermistor-based sensing grid and microprocessor-based electronics panel for flow averaging temperature compensation and signal transmission.
- .2 Water flow In –Line Type: for Pipe Sizes up to 1.5 inches (38mm) in line type flow sensor shall have a nonmagnetic spinning impeller.
- .3 Water flow Insertion Type: for Pipe 1.5 to 10 inches (38 to 254mm) provide a probe mounted insertion type turbine sensor.

2.12 VELOCITY PRESSURE SENSORS

- .1 Sensors Requirements:
 - .1 Multipoint static and total pressure sensing element with self-averaging manifold with integral air equalizer and straightener section.
 - .2 Maximum pressure loss: 37 Pa at 1000 m/s
 - .3 Accuracy: plus or minus 1% of actual duct velocity.

2.13 VELOCITY PRESSURE TRANSMITTERS

- .1 Transmitters Requirements:
 - Output signal: 4-20 mA linear into 500-ohm maximum load.
 - Calibrated span: not to exceed 125% of duct velocity pressure at maximum flow.
 - Accuracy: 4% of span.
 - Repeatability: within 0.1% of output.
 - Linearity: within .5% of span.
 - Dead-band or hysteresis: 0.1% of span.

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2.14 LIQUID AND STEAM FLOW METERS

- .1 Requirements: In accordance with CITY OF MISSISSAUGA Master Metering Specifications. Request copy from CITY OF MISSISSAUGA Facilities Project Manager when quoting a new project.

2.15 DIFFERENTIAL PRESSURE TRANSMITTERS & TRANSDUCERS

- .1 Differential pressure transmitters shall be made of suitable materials for continuous contact with the process materials such as: compressed air water, glycol or steam etc.
- .2 Output signal of 4-20 mA or equivalent, output short circuit and open circuit protection.
- .3 Output variations: less than .2% full scale for supply voltage variations of plus or minus 10%.
- .4 The controller shall determine airflow by dynamic pressure measurement using an integral dead-end differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters
- .5 The controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature, humidity effects.

2.16 ELECTRIC/PNEUMATIC TRANSDUCERS (EPT) OR ELECTRIC/RESISTANCE TRANSDUCERS (ERT)

- .1 Provide electric pneumatic transducers and/or electric resistance transducers that apply to the operation characteristics required in the specifications.
- .2 The EPT shall have a nominal output 1 to 20 PSI, an adjustment span of 2 to 20 SPI, 5% span, and zero adjustment from 1 to 18 PSI.
- .3 The ETR shall have a minimum of 3 linear rheostats, having a 5% tolerance.
- .4 Each transducer shall have analog input adjustment point.
- .5 Supply with each EPT a positive feedback system (pneumatic electric transducer PET) allowing a feedback of the demand from the pneumatic control signal to the controlled devices.
- .6 Each pneumatic and/or electric control adjustment shall allow DDC to maintain the last output command during a malfunction or a power control failure of the control panel.

2.17 CURRENT SENSING RELAYS

- .1 Current sensing relays shall be Carlo Gavazzi, 120 VAC, plug in type with remote sensor (donut). Relays shall be properly secured to cabinet/device enclosure using DIN rail or other manufacturer approved method

2.18 ELECTRIC RELAYS

- .1 Electric control relays shall be double pole double throw with 24V or 120 V nominal (DPDT) coils. Contacts rated 10 amps at 120 VAC, plug-in type with sub-base, and wiring terminal blocks.
- .2 Contacts shall be rated for 10 amps at 120 AC

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- .3 Relays shall have an integral indicator light and check button.

2.19 FRACTIONAL HORSEPOWER MOTOR CONTROL

- .1 For fractional HP motors (i.e. Exhaust Fans) to be controlled by the EMCS, new starters shall be Veris Hawkeye H548.
- .2 Shall be used for monitoring motor status and providing Hand/Off/Auto control of the FHP motor.

2.20 PRESSURE SWITCHES

- .1 Pressure switches shall have Bourdon tube, bellows or diaphragm type sensing element. Pressure switches shall be snap action type, voltage rated at 120 VAC, 15 AMPS or 24 volts DC, with adjustable setpoint and differential.
- .2 Sensing element shall be isolated between the sensor and the pressure source (steam, high temperature hot water, etc.)
- .3 Pressure switch range shall be according to their application and shall be commercial building industry standard.

2.21 CURRENT ELECTRIC TRANSDUCERS

- .1 Current electric transducers shall measure line current and produce a proportional signal with the following range:
- 4 – 20 Ma
 - 0 – 1 VDC
 - 0 – 10 VDC
 - 0 – 20 VDC
 - 2 – 10 VDC
- .2 Frequency insensitive from 10-80 Hz
- .3 Accuracy to 0.5% full scale.
- .4 Zero and span adjustments. Field adjustable range to suit motor applications.
- .5 Adjustable mounting bracket to allow for secure/safe mounting inside MCC.

2.22 ELECTRONIC SIGNAL ISOLATION TRANSDUCERS

- .1 The signal isolation transducer shall be provided whenever an analog output signal from BAS is to be connected to an external control system as an input or is to receive as input signal from remote system.

2.23 SUMP LEVEL SWITCHES

- .1 Requirements:
- Indicate high/low water level and to alarm.
 - Maximum operating temperature: 120°C.
 - Snap action contacts rated (15 amp at 120 V)
 - Adjustable set-point and differential.

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2.24 TANK LEVEL SWITCHES

- .1 Switches shall be sealed mercury tube type in waterproof and shockproof enclosure. Contacts shall be rated 15 amps at 120 VAC.

2.25 WIND VELOCITY TRANSMITTERS

- .1 Requirements:
 - .1 3-cup anemometer and airfoil vane mounted on common vertical axis, designed for mast mounting.
 - .2 Anemometer:
 - Range: 0-160 km/h.
 - Threshold: 3.0 km/h.
 - Accuracy: +/- 2%.
 - .3 Airfoil vane
 - Range: 0-360 degrees with infinite resolution potentiometer with no loss of reading at transition point.
 - Starting threshold: 1.1 M/s.
 - Accuracy: +/- 0.5%.
 - Output signals: 4 to 20 Ma into 500-ohm load.
 - Provide two output signals: velocity, direction.
 - Mast: aluminum, size and height as indicated.
 - Provide at least 3 stainless steel guys, turnbuckles, anchor bolts. Follow manufacturer's installation guidelines.
 - Lightning protection as indicated on electrical drawings.

2.26 SOLAR SENSORS

- .1 Monitor solar radiation as indicated.
- .2 Pyranometer, black and white, producing proportional 0-50 mV signal. Include converter for 4-20 mA signal.

2.27 PLC MULTIPOINT DAYLIGHT HARVESTING PHOTSENSOR

- .1 Monitor lighting levels for control of lighting systems as indicated.
- .2 Kele Model: MK7-B-CR (0-10Vdc or 4-20ma)
- .3 Supply Voltage: 12-24 VDC, 20 mA max
- .4 Analog Output: (model specific) 4-20 mA @ 850Ω, or 0-10VDC @ 5KΩ min
- .5 Range Adjust & Response Time: Field adjustable
- .6 Operating Conditions: -40° to 140°F (-40° to 60°C); 10% to 95% RH Non-condensing
- .7 Wiring Terminations: 3 wire 18 AWG pigtails
- .8 Mounting:
 - Indoor (-CCF): Smooth back for ceiling down mounting w/double stick tape

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- Outdoor (-CR):1/2" MNPT for Horizontal mount
 - Skylight (-CS):1/2" MNPT for Vertical-up mount
- .9 Enclosure Rating: NEMA 1-Indoor (-CCF) and Skylight (-CS), NEMA 3R Outdoor (-CS)
- .10 Warranty:2 year

2.28 SURFACE WATER DETECTORS

- .1 Requirements:
- Provide alarm on presence of water on floor.
 - Expendable cartridge sensor.
 - Internal waterproof switch.
 - One set of dry contacts 2 amps at 24 V.
 - Unaffected by moisture in air.
 - Self-powered.

2.29 ELECTRONIC DAMPER ACTUATORS

- .1 Electronic damper actuators shall be direct shaft mount. The actuator shall be direct couple over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches. Single bolt or screw type fasteners are not acceptable.
- .2 Modulating and two-position actuators shall be provided as required by the sequence of operations.
- .3 The actuator mounting arrangement and spring return ``fail-safe`` feature shall permit normally open or normally closed positions of the dampers, as required.
- .4 The actuator shall be size to control dampers against maximum pressure and dynamic closing/opening pressure, whichever is greater.
- .5 All actuators (except terminal units i.e. VAV boxes etc.) shall be furnished with mechanical spring return unless otherwise specified in the sequence of operations.
- .6 All actuators shall have external adjustable stops to limit the travel in either direction, or gear release to allow manual positioning.
- .7 Power requirements: Modulating actuators shall accept 24 VAC or VDC power supply, consume no more 15 VA. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator provide position feedback signal of 2-10 VDC.
- .8 The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication.
- .9 For VAV box applications floating control type actuators may be used.
- .10 Damper actuators shall drive damper from fully open to fully closed, in less than 120 seconds.

EMCS: FIELD CONTROL DEVICES

- .11 Actuators shall be designed for a minimum of 100,000 full stroke cycles and 1,000,000 part cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of start-up.

2.30 ELECTRONIC / ELECTRIC VALVE ACTUATORS

- .1 Each actuator shall be equipped with current limiting circuitry incorporated in its design to prevent damage to the actuator.
- .2 Modulating and two-position actuators shall be provided as required by the sequence of operations.
- .3 The actuators shall provide the minimum torque required for proper valve close-off against system pressure for the required application.
- .4 All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations.
- .5 The spring return feature shall permit normally open or closed positions of the valves a, specified.
- .6 All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
- .7 Scale or dial indication of actual control valve position.
- .8 Size actuator to meet requirements (CV's) and performance of the control valve specifications.
- .9 For interior and perimeter heating and cooling applications floating control actuators are acceptable.
- .10 Power requirements: Modulating actuators shall accept 120 VAC or 24 VDC power supply, consume no more 15 VA. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator provide position feedback signal of 2-10 VDC.
- .11 The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication.
- .12 Two- position or open/ closed actuators shall accept 24Vdc or 120 VAC power supply.
- .13 Butterfly isolation and other valves, as specified in the sequence of operations, shall furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated heating /cooling pump or chiller.

2.31 POWER AND ELECTRIC CONSUMPTION TRANSDUCER

- .1 Power transducers shall measure the electric power in Kilowatts (proportional signal) with ranges of 4 to 20 mA, 0 TO 5 VDC, 2-10 VDC, 0 to 20 VDC and shall measure electric consumption in KWH (pulsed signal).
- .2 Power transducers shall have a local LCD display on the unit of instantaneous power (kW) and shall be VERIS model #H6004.

2.32 POWER SUPPLIES

- .1 General

EMCS: FIELD CONTROL DEVICES

- .1 DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
 - Input: 120 VAC +10% line change.
 - Output: 24 VDC.
 - Load Regulation: +0.05% for 50% load change.
 - An appropriately sized fuse and fuse block shall be provided and located next to power supply.
- .2 A lockable power disconnect switch shall be provided next to the power supply or as an integral component of the power supply.
- .3 The 120-Volt circuits used for the BAS shall be dedicated to the BAS and shall not be used for any other purposes.
- .4 Each BAS Control Panel (including the Building Controller) shall have a “packaged” Power Supply in a separate enclosure, such that the BAS Control Panel door can be opened without exposure to the 120-Volt wiring connections (Arc-Flash hazard) (see 2.33.5)
- .2 Uninterrupted Power Supply (UPS)
 - .1 The UPS unit shall be supplied by a 120 VAC source and shall have enough capacity (VA) to support the associated SRPDC. The UPS shall be continuous operation type with battery reserve of 30 minutes minimum (at full charge) during a power failure. The UPS shall have internal fuse protection. The UPS shall supply the Communication Interface as well (if applicable). The primary role of the UPS shall be to maintain the primary RPDC microprocessor function as well as the modules for input/output points. This will allow the reading of data from the SRPDC in continuous mode and at the central computer via the communication network during the delay of the generator start-up.
 - .2 In absence of power failure, the internal rectifier and sine wave circuit of the UPS allows the UPS to regulate the power supply to the CNP ex. Frequency, voltage variation, etc.
 - .3 The UPS shall be supplied and installed by the EMCS contractor and shall be of the following type: Power Ware Model BE850M2 or approved equivalent. The UPS shall be a true UPS meaning the inverter shall be active at all times, not just on a loss on input power. The UPS (and all DDC equipment) shall powered through dedicated circuit(s) from the nearest power panel. The UPS shall be monitored and signal an alarm to the DDC system when the UPS batteries are dead
- .3 Other Primary Elements

All other primary elements shall be of the highest quality for commercial building industry. The precision shall be (+/-) 1% of the normal reading for the application.

2.33 PANELS

- .1 Wall mounted NEMA 1 enamelled steel cabinets with hinged and key-locked front door.
- .2 Multiple panels as required to handle requirements with additional space to accommodate 25% additional capacity as without adding additional cabinets.
- .3 Panels shall have DIN Rail mounting for controllers, relays, and other control devices.

EMCS: FIELD CONTROL DEVICES

- .4 Panel shall have separate color coded terminal strip for termination of end devices (sensors, relays, etc) entering panel, and then from terminal strip to the termination point on controller. End devices shall not be wired directly to controller.
- .5 Panels shall have external 120Vac to 24Vdc transformer. There shall be no 120V wiring inside of panel enclosure.
- .6 Panels shall have plastic raceway/cable tray system for routing of wires into/out of panel.
- .7 All panels shall be installed with Termination diagram showing the proper point names or each wire into panel, where it terminates on the terminal strip and where the wiring from terminal strip terminates at controller.
- .8 Panels to be lockable with same key.
- .9 Color Grey

Part 3 Execution

3.1 INSTALLATION

- .1 The contractor shall inform the owner and receive a written approval for the installation location of all field control devices, before any installation
- .2 The contractor should examine projects plans for control devices and equipment locations, and report any discrepancies, conflicts, or omissions to the project manager for resolution before proceeding for installation. The contractor should examine projects plans for control devices and equipment locations, and report any discrepancies, conflicts, or omissions to the project manager for resolution before proceeding for installation.
- .3 The Contractor shall supply all primary elements as indicated on the drawings and as described in the sequences of operation. It includes all sensors, contacts for the analog and binary inputs and includes all controllers, relays and controlled devices necessary for the analog and binary outputs.
- .4 The Contractor shall make all the final connections to the new elements to render a complete and operational control system.
- .5 All sensors, transmitters, instruments, etc. which are to be replaced to permit the installation of the new system, shall be replaced with corresponding ones according to the new specifications. The Contractor shall present shop drawings for approval to the Owner before ordering the equipment.
- .6 All holes made in ducts for the installation of primary elements shall be sealed properly in order not to affect the readings due to ambient air aspirating through these holes.
- .7 Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
- .8 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

EMCS: FIELD CONTROL DEVICES

- .9 Install equipment, piping, cables, wiring/conduit parallel to or right angles to building lines. Refer to Category 6 Structured Cabling specification in Appendix C for additional requirements.
- .10 Fabricated control panels built to support auxiliary devices such power supplies, relays, controllers, and control devices.
- .11 Install all sensors and instrumentation according to manufacturer's instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
- .12 Install room sensors prenatally supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above finished floor.
- .13 The blank stainless steel wall plate sensors shall be flush mounted directly to a single gang electrical box or directly to a wall. Insulating foam is adhered to the back of the wall plate in order to provide a thermal barrier from internal wall temperatures.
- .14 Install equipment, components so that manufacturer's and CSA labels are visible and legible after commissioning is complete.
- .15 Install field control devices in accordance with manufacturers recommended methods, procedures and instructions.
- .16 Temperature transmitters, humidity transmitters, current-to-pneumatic transducers, solenoid air valves, controllers, relays: install in NEMA I enclosure or as required for specific applications. Provide for electrolytic isolation in cases when dissimilar metals make contact.
- .17 Support field-mounted panels, transmitters and sensors on pipe stands or channel brackets.
- .18 Fire stopping: provide space for fire stopping in accordance with Section 07 84 00 - Firestopping. Maintain fire rating integrity.
- .19 Electrical:
 - .1 Complete installation in accordance with Local, Provincial and National Electrical Codes
 - .2 Modify existing starters to provide for EMCS as indicated in points list.
 - .3 Refer to electrical control schematics as supplied by equipment manufacturer's installation manual. Trace any existing control wiring installation and provide updated wiring schematics including additions, deletions to control circuits for review by Consultant before beginning Work.
 - .4 Terminate wires with screw terminal type connectors suitable for wire size, and number of terminations.
 - .5 Where exposed install communication wiring in conduit. Above rated ceiling, contractor may run plenum rated cable neatly tie wrapped to existing structure.
 - .1 Provide complete conduit system to link all Controllers and field devices.
 - .2 Conduit sizes to suit wiring requirements and to allow for future expansion capabilities specified for systems.
 - .3 Maximum conduit fill not to exceed 40%.
 - .4 Design drawings do not show conduit layout.

EMCS: FIELD CONTROL DEVICES

3.2 IDENTIFICATION

- .1 Identify field devices in accordance with Section 25 05 54 - EMCS: Identification.

3.3 AIR FLOW MEASURING STATIONS

- .1 Protect air flow measuring assembly until cleaning of ducts is completed.

3.4 TESTING AND COMMISSIONING

- .1 Calibrate and test field devices for accuracy and performance in accordance with Section 25 01 11 - EMCS: Start-up, Verification and Commissioning.

END OF SECTION 25 30 01

**EMCS: SITE REQUIREMENTS, APPLICATIONS AND SYSTEMS
SEQUENCES OF OPERATION**

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EMCS: SITE REQUIREMENTS, APPLICATIONS AND SYSTEMS SEQUENCES OF OPERATION

Part 1 General

1.1 SUMMARY

1.1.1 Section Includes:

- 1.1.1.1 Generic Sequence of Operation that are common to City of Mississauga Energy Management Control System (EMCS) Installations.

1.1.2 Related Sections:

- 1.1.2.1 Section 01 33 00 – Submittal Procedures
- 1.1.2.2 Section 01 77 00 – Closeout Procedures
- 1.1.2.3 Section 25 05 01 - EMCS: General Requirements
- 1.1.2.4 Section 25 05 02 - EMCS: Submittals and Review Process.
- 1.1.2.5 Appendix A – CoM Standards and Guidelines

1.1.3 References:

- 1.1.3.1 Not Used

1.2 SUBMITTALS

- 1.2.1 Provide Submittal drawings in accordance with Section 01 33 00 Submittal Procedures and Section 25 05 02 EMCS Submittals and Review Process.

1.2.2 Submittals information shall include:

- 1.2.2.1 A detailed narrative description of Sequence of Operation of each system including initial ramping periods and reset schedules.
- 1.2.2.2 Control Description Logic (CDL) for each system.
- 1.2.2.3 Completed Input/Output Point Matrix Summary Tables populated with COM point naming conventions for each system and related equipment/device fields.
- 1.2.2.4 System Diagrams consisting of the following: EMCS System architectural diagram, Control Design Schematic for each system (as viewed on OWS), System flow diagram for each system with electrical ladder diagram for MCC starter interface.
- 1.2.2.5 Final As-Built submittals shall be updated to reflect the final conditions upon completion of installation and commissioning process. A link to PDF version of as-builts shall be provided on all pages of graphical user interface, specific to the system on that graphical page (i.e. – RTU1 shall have link to Sequence and Wiring Diagrams for RTU1, RTU2...)

1.3 SEQUENCES OF OPERATION

1.3.1 Application of Specified Sequences

- 1.3.1.1 The CoM Typical Points List and Standard Sequence of Operation can be found in Appendix A CoM Standards and Guidelines. The sequences are generic in nature and are meant to form the basis of design for all CoM EMCS Projects

EMCS: SITE REQUIREMENTS, APPLICATIONS AND SYSTEMS SEQUENCES OF OPERATION

1.3.1.2 The sequences shall be used as the initial starting point for each project, customized by the specifying Consultant and tailored for the specifics of individual project and system requirements.

1.3.1.3 All project specific sequences to be submitted to the CoM for review and approval prior to Tender. – Refer to **EMCS Design Guidelines**, Approval Process.

1.3.2 HVAC Operating Schedules & Modes

1.3.2.1 Refer to **CoM Typical Points List and Standard Sequence of Operation**, in Appendix A

1.3.3 System Sequences

1.3.3.1 Refer to **CoM Typical Points List and Standard Sequence of Operation**, in Appendix A

Part 2 Products

2.1 NOT USED

2.1.1 Not Used.

Part 3 Execution

3.1 NOT USED

3.1.1 Not Used.

END OF SECTION 25 90 01

Common Work Results - Electrical

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Part 1 General

1.1 RELATED SECTIONS

- 1.1.1 Section 25 05 01 EMCS General Requirements
- 1.1.2 Section 25 30 01 EMCS Building Family of Controllers
- 1.1.3 Section 25 30 02 EMCS Field Control Devices

1.2 REFERENCES

- 1.2.1 Canadian Standards Association (CSA International)
 - 1.2.1.1 CSA C22.1, Canadian Electrical Code, Part 1 (20th Edition), Safety Standard for Electrical Installations.
 - 1.2.1.2 CSA C22.2.
- 1.2.2 CAN/CSA-C22.3 No. 1, Overhead Systems.
- 1.2.3 CAN3-C235, Preferred Voltage Levels for AC Systems, 0 to 50,000 V.
- 1.2.4 Electrical and Electronic Manufacturer's Association of Canada (EEMAC)
- 1.2.5 EEMAC 2Y-1 , Light Gray Colour for Indoor Switch Gear.
- 1.2.6 Institute of Electrical and Electronics (IEEE)/National Electrical Safety Code Product Line (NESC)
- 1.2.7 IEEE SP1122, The Authoritative Dictionary of IEEE Standards Terms, 7th Edition.

1.3 DEFINITIONS

- 1.3.1 Electrical and electronic terms: unless otherwise specified or indicated, terms used in these specifications, and on drawings, are those defined by IEEE SP1122.
- 1.3.2 This section covers items common to Sections of Division 26. This section supplements requirements of General Conditions, Supplemental General Conditions and the General Requirements of these specifications.
- 1.3.3 This Contractor shall be responsible for all cutting and patching required for the removal of existing and installation of new electrical services associated with mechanical systems as indicated and/or specified within.
- 1.3.4 Where there is a discrepancy between these specifications on those on the drawings, the drawing shall be taken as correct.

Part 2 Codes and Standards

2.1 GENERAL

- 2.1.1 Do complete installation in accordance with CSA C22.1-1990 and Ontario Hydro code requirements except where specified otherwise.
- 2.1.2 Do overhead and underground systems in accordance with CSA C22.3No.1-M1979 except where specified otherwise.
- 2.1.3 Abbreviations for electrical terms: to CSA Z85-1983.

Common Work Results - Electrical

- 2.1.4 Comply with most recent electrical, building and other applicable codes and authorities having jurisdiction. All new equipment must be CSA approved or approved by special Ontario Hydro inspection.

Part 3 Execution

3.1 CARE, OPERATION AND START-UP

- 3.1.1 Instruct Consultant and operating personnel in the operation, care and maintenance of equipment.
- 3.1.2 Arrange and pay for services of manufacturer's factory service engineer to supervise start-up of installation, check, adjust, balance and calibrate components.
- 3.1.3 Provide these services for such period, and for as many visits as necessary, to put equipment in operation and ensure that operating personnel are conversant with all aspects of its care and operation.

3.2 VOLTAGE RATINGS

- 3.2.1 Operating voltages: to CAN3-C235-83.
- 3.2.2 Motors, electric heating, control and distribution devices and equipment to operate satisfactorily at 60 Hz within normal operating limits established by above standard. Equipment to operate in extreme operating conditions established in above standard without damage to equipment.
- 3.2.3 Voltage drop: voltage drop on new systems wired under this contract shall not exceed 3%. Provide calculations at the request of consultant.

3.3 PERMITS, FEES AND INSPECTION

- 3.3.1 Submit to Electrical Inspection Department and Supply Authority necessary number of drawings and specifications for examination and approval prior to commencement of work.
- 3.3.2 Pay associated fees. Apply for, obtain and pay for all permits, licences, inspections, examinations and fees required.
- 3.3.3 Ameresco will provide drawings and specifications required by Electrical Inspection Department and Supply Authority at no cost.
- 3.3.4 Notify Ameresco of changes required by Electrical Inspection Department prior to making changes. Comply with any changes requested prior to making changes.
- 3.3.5 On completion of work, furnish to the Owner Certificates of Acceptance from authorities having jurisdiction.

3.4 MATERIALS AND EQUIPMENT

- 3.4.1 Provide materials and equipment in accordance with these specifications and associated drawings.
- 3.4.2 Equipment and material to be CSA certified. Where there is no alternative to supplying equipment that is not CSA certified, obtain special approval from Electrical Inspection

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Department of governing authority. Should any dispute arise as to quality or fitness of products, decision rests strictly with Ameresco based on requirements of Contract Documents.

- 3.4.3 Factory-assemble control panel and component assemblies.

3.5 ELECTRIC MOTORS, EQUIPMENT AND CONTROLS

- 3.5.1 Control wiring and conduit is specified in Division 26 except for conduit, wiring and connections for direct digital controls, which are related to control systems specified in Division 25 (**All other controls, interlocks, etc shall be by Division 26**).

3.6 FINISHES

- 3.6.1 Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two (2) coats of finish enamel.
- 3.6.2 Clean and touch-up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.
- 3.6.3 Clean and prime exposed non-galvanized hangers, racks and fastenings to prevent rusting.

3.7 EQUIPMENT IDENTIFICATION

- 3.7.1 Identify electrical equipment with nameplates in accordance with existing building nomenclature.
- 3.7.2 Nameplates
- 3.7.2.1 Lamacoid 3 mm thick plastic engraving sheet, black face, white core.

Nameplate Sizes:

Size 1	10 x 50 mm	1 line	3 mm high letters
Size 2	12 x 70 mm	1 line	5 mm high letters
Size 3	12 x 70 mm	2 lines	3 mm high letters
Size 4	20 x 90 mm	1 line	8 mm high letters
Size 5	20 x 90 mm	2 lines	5 mm high letters
Size 6	25 x 100 mm	1 line	12 mm high letters
Size 7	25 x 100 mm	2 lines	6 mm high letters

3.7.3 Labels

- 3.7.3.1 Embossed plastic labels with 6 mm high letters unless specified otherwise.
- 3.7.3.2 Wording on nameplates to be approved by Consultant prior to manufacture.
- 3.7.3.3 Allow for average of 25 letters per nameplate.
- 3.7.3.4 Identification to be English.
- 3.7.3.5 Nameplates for terminal cabinets and junction boxes to indicate system and/or voltage characteristics.
- 3.7.3.6 Disconnects, starters and contactors: indicate equipment being controlled and voltage.
- 3.7.3.7 Terminal cabinets and pull boxes: indicate system and voltage.

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3.7.3.8 Transformers: indicate capacity, primary and secondary voltages.

Common Work Results - Electrical

3.8 WIRING IDENTIFICATION

- 3.8.1 Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.
- 3.8.2 Maintain phase sequence and colour coding throughout.
- 3.8.3 Colour code: to CSA C22.1-1990.
- 3.8.4 Use colour coded wires in communication cables, matched throughout system.

3.9 CONDUIT AND CABLE IDENTIFICATION

- 3.9.1 Colour code conduits, boxes and metallic sheathed cables.
- 3.9.2 Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 15 m intervals
- 3.9.3 Colours: 25 mm wide prime colour and 20 mm wide auxiliary colour.

	Prime	Auxiliary
up to 250 V	yellow	
up to 600 V	yellow	green
up to 5 kV	yellow	blue
up to 15 kV	yellow	red
Telephone	green	
Other communication systems	green	blue
Fire alarm	red	
Emergency voice	red	blue
Other security systems	red	yellow

3.10 WIRING TERMINATIONS

- 3.10.1 Lugs, terminals, and screws used for termination of wiring to be as specified on drawings.

3.11 MANUFACTURER'S AND CSA LABELS

- 3.11.1 Must be visible and legible after equipment is installed.

3.12 WARNING SIGNS

- 3.12.1 As specified and to meet requirements of Electrical Inspection Department and Consultant.
- 3.12.2 Decal signs, minimum size 175 x 250 mm.

3.13 MOUNTING HEIGHTS

- 3.13.1 Mounting height of equipment is from finished floor to centreline of equipment unless specified or indicated otherwise.
- 3.13.2 If mounting height of equipment is not specified or indicated, verify before proceeding with installation.

Common Work Results - Electrical

3.13.3 Install electrical equipment at following heights unless indicated otherwise.

- 3.13.3.1 Local switches: 1,400 mm
- 3.13.3.2 Wall receptacles:
- 3.13.3.3 General: 300 mm.
- 3.13.3.4 Above top of continuous baseboard heater: 200 mm.
- 3.13.3.5 Above top of counters or counter splash backs: 175 mm
- 3.13.3.6 In mechanical rooms: 1,200 mm.
- 3.13.3.7 Panelboards: as required by Code or as indicated.
- 3.13.3.8 Telephone and interphone outlets: 300 mm.
- 3.13.3.9 Wall-mounted telephone and interphone outlets: 1,500 mm.
- 3.13.3.10 Fire alarm stations: 1,500 mm.
- 3.13.3.11 Fire alarm bells: 2,100 mm.
- 3.13.3.12 Television outlets: 300 mm.
- 3.13.3.13 Wall-mounted speakers: 2,100 mm
- 3.13.3.14 Clocks: 2,100 mm
- 3.13.3.15 Doorbell pushbuttons: 1,500 mm

3.14 LOAD BALANCE

- 3.14.1 Measure phase current to panelboards with normal loads operating at time of acceptance. Adjust branch circuit connections as required to obtain best balance of current between phases and record changes.
- 3.14.2 Measure phase voltages at loads and adjust transformer taps to within 2% of rated voltage of equipment.
- 3.14.3 Submit, at completion of work, report listing phase and neutral currents on panelboards, dry-core transformers and motor control centres, operating under normal load. State hour and date on which each load was measured, and voltage at time of test.

3.15 CONDUIT AND CABLE INSTALLATION

- 3.15.1 Install conduit and sleeves prior to pouring of concrete. Sleeves through concrete: schedule 40 steel pipe, sized for free passage of conduit, and protruding 50 mm.
- 3.15.2 Install cables, conduits and fittings to be embedded or plastered over, neatly and close to building structure so furring can be kept to minimum.

Part 4 Field Quality Control

4.1 TESTING

- 4.1.1 Conduct and pay for following tests:
 - 4.1.1.1 Power distribution system including phasing, voltage, grounding and load balancing.
 - 4.1.1.2 Circuits originating from branch distribution panels.
 - 4.1.1.3 Lighting and its control.

Common Work Results - Electrical

4.1.1.4 Motors, heaters and associated control equipment including sequenced operation of systems where applicable.

4.1.2 Furnish manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to manufacturer's instructions.

4.2 INSULATION RESISTANCE TESTING.

4.2.1.1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.

4.2.1.2 Megger 350-600 V circuits, feeders and equipment with a 1,000 V instrument.

4.2.1.3 Check resistance to ground before energizing.

4.2.2 Carry out tests in presence of Consultant.

4.2.3 Provide instruments, meters, equipment and personnel required to conduct tests during and at conclusion of project.

4.2.4 Submit test results for Consultant to review.

4.3 CO-ORDINATION OF PROTECTIVE DEVICES

4.3.1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings.

END OF SECTION 26 05 00

Appendix A: City of Mississauga Standards & Guidelines

Appendix A City of Mississauga Standards and Guidelines

- A1- CoM Point Naming Convention**
- A2- CoM Building ID and Type List**
- A3- CoM EMCS Cabinet Installation Standard**
- A4- CoM System Architectures**
- A5- CoM Graphical Standard**
- A6- CoM Points List and Typical Sequences of Operation**

Appendix A1

CITY OF MISSISSAUGA

POINT NAMING CONVENTION

GUIDE RULES

All objects must be defined with the site number followed by system identifier, Device Location (Floor number or area) and the point Description. (See acronym list)

EXAMPLE: Building Name: Iceland Arena Site ID: IA1

Acronym	System Identifier	Device/Equip	Action/Feedback
SITE ID	Dehumidifier 1	Supply Fan	Command
IA1	DH1	SF	CMD

Point Name: IA1_DH1SF_CMD

Acronym	System Identifier	Device/Equip	Action/Feedback
SITE ID	Air Handling Unit 1	MA Damper	Modulate
IA1	AHU1	MADPR	MOD

Point Name: IA1_AHU1MADPR_MOD

Acronym	System Identifier	Device/Equip	Action/Feedback
SITE ID	Boiler 1	Boiler Alarm	Alarm
IA1	BLR1	ALM	ALM

Point Name: IA1_BLR1ALM_ALM

Acronym	System Identifier	Device/Equip	Action/Feedback
SITE ID	Boiler1	Supply Water Temp	Temperature
IA1	BLR1	SWT	T

Point Name: IA1_BLR1SWT_T

Table 1: City of Mississauga Sample Facility Identification Tags
For Complete List of Facility ID Tags please see Appendix A2 – Facility ID and Building Type

Facility	Site ID
Burnhamthorpe Community Centre & Arena	BCC1
Burnhamthorpe CC Parks Bunker/Change House	BCC2
Burnhamthorpe CC Covered Outdoor Rink	BCC3
Carmen Corbasson/Cawthra Community Centre & Arena	CAW1
Mississauga Senior Citizens Centre	CAW2
Port Credit Lawn Bowling Club	CAW3
Iceland Arena	IA1
Iceland Arena & Sports Park Electrical Bunker	IA2
Iceland Arena & Sports Park Park Bunker (not FPM)	IA3
Iceland Arena & Sports Park Gazebo	IA4

Table 2: Typical System Tags

Equipment Description	Tag
Air Handling Unit (Indoor)	AHU
Rooftop Air Handler (Outdoor)	RTU
Make Up Air Handler (100% OA)	MUA
Energy Recovery Ventilator	ERV
Heat Recovery Ventilator	HRV
Exhaust Fan	EF
Dehumidifier	DH
Unit Ventilator	UV
Fan Coil	FC
Heat Pump	HP
Boiler	BLR
Radiator	RAD
Chiller	CHLR
Cooling Tower	CT
Air Cooled Condenser	CND
Refrigeration Plant Compressor	CMPR
Lighting	LTG
Generator	GEN
Evaporative Condenser	ECND
Fluid Cooler	FCL
Domestic Hot Water Tank	DHWT
Refrigeration (ice) Plant	ICEP
Heat Exchanger	HX
Radiant Heater	RADH
Unit Heater	UH
Pool	Pool
Steam Generator	SGEN
Elevator Sump Pump	ESUMP
Fire Alarm	FIRE
Gas Detection System	GASD
Reclaimed Rain Water System	RRWS
Electric System	ELEC
Meters (Gas-NG, Water - WT, Hydro-ELC)	xxMTR

Table 2: Typical Device Tags

Device Description	Tag
Supply Fan	SF
Return Fan	RF
Exhaust Fan	EF
Supply Fan VSD	SFVSD
Return Fan VSD	RFVSD
Heating Control Valve	HTGVLV
Cooling Valve	CLGVLV
Differential Pressure Valve	DPVLV
Refrigeration Solenoid Valve	DXVLV
Make-Up Water Valve	MUWVLV
Reversing Valve	REVLV
Drain Valve	DRVLV
Burner	BUR
Damper	DPR
Filter	FILT
Freeze Stat	FRZ
Occupancy Sensor	OCC
Room Temperature Sensor/Thermostat	RMT
Return Air Temperature Sensor	RAT
Return Air Humidity Sensor	RAH
Return Air Static Pressure	RASP
Supply Air Temperature Sensor	SAT
Supply Air Humidity Sensor	SAH
Supply Air Static Pressure Sensor	SASP
Heating Pump	HTGPMP
Cooling Pump	CLGPMP
Condenser Water Pump	CNDPMP
Condensate Pump	CONPMP
Domestic Water Recirc Pump	DWRPMP
Domestic Water Booster Pump	DWBPMP
Cold Brine Pump	CBPMP
Warm Brine Pump	WBPMP
Glycol Pump	GLPMP
Compressor Jacket Pump	CJPMP
Mixed Air Temperature Sensor	MAT
Differential Pressure Sensor	DP

Table 3: Typical Point Type & Units

Point Type	Description	Tag	Typical Units
DI	Status	STS	Open/Closed
			On/Off
			Alarm/Normal
			Occupied/Unoccupied
AI	Status	STS	Amps
	Level	LVL	ppm
			Lux
	Relative Humidity	RH	%RH
	Temperature	T	°C
	Feedback	FBK	Hz
			%
	Pressure	PRS	Psi
DO	Setpoint	SPT	(Variant)
	Flow	FLOW	L/s
DO	Command	CMD	Open/Close
			On/Off
	Alarm	ALM	Alarm/Normal
AO	Modulate	MOD	% Open
			%
			% Fresh Air
COM	Communication Protocol BacNet/LON/Modbus	VP	As defined by the available read/write permissions of the specified equipment.

EXAMPLE POINT NAMES

Single Zone AHU Systems

Anticipated Points:

AHUxSF-STS	- Supply Fan Status (1 DI)
AHUxSF-CMD	- Supply Fan Start/Stop (1 DO)
AHUxRF-STS	- Return Fan Status (1 DI)
AHUxRF-CMD	- Return Fan Start/Stop (1 DO)
AHUxMAT-T	- Mixed Air Temp (AI)
AHUxMADPR-MOD	- Mixed Air Dampers CTL (1 AO)
AHUxSAT-T	- Supply Air Temp (1 AI)
AHUxRAT-T	- Return Air Temp (1 AI)
AHUxHTGVLV-MOD	- Heating Coil Valve CTL (1 AO)
AHUxHTGPMP-CMD	- Heating Coil Pump CMD (1 DO)
AHUxHTGPMP-STS	- Heating Coil Pump Status (1 DI)
AHUxCLGVLV-MOD	- Cooling Coil Valve CTL (1 AO)

VAV Terminal Control

Points

VAV###RMT-T	- VAV Rm ### Space Temp (1 AI)
VAV###RMT-SPT	- Room Temp Set Point (1 AI)
VAV###OCC-STS	- Occu Button/Sensor Status (1 DI)
VAV###VP-PRS	- VAV Velocity Pressure (1 AI)
VAV###FLW-LPS	- VAV Total Air Flow (1 AI)
VAV###DPR-MOD	- VAV Damper Modulation (1 AO)
<i>Optional w/Reheat</i>	
VAV###HTGVLV-MOD	-VAV Htg Valve Modulation (1 AO)
VAV###SAT-T	-Supply Air Temp (1 AI)

Refer to Appendix A6 for a list of Typical Points and Standard CoM Sequences of Operation.

Appendix A2

City of Mississauga Facility ID Numbers and Building Types

Building ID	Description	Address	Building Type
ACC1	Animal Services Centre	735 CENTRAL PKY W	WRKPRK-DEP
AE1	Adamson Estate Main House-Heritage Designation	850 ENOLA AVE	PARK-OTHER
AE2	Adamson Estate Derry House-Heritage Designation	875 ENOLA AVE	PARK-OTHER
AE3	Adamson Estate Folly-Heritage Designation	850 ENOLA AVE	PARK-OTHER
AE4	Adamson Estate Barn-Heritage Designation	850 ENOLA AVE	PARK-OTHER
AEC1	A.E. Crookes Park Clubhouse & Concession Stand	140 LAKEFRONT PROMENADE	REC-MINOR
AEC2	A.E. Crookes Park Storage Building	140 LAKEFRONT PROMENADE	REC-BNKSTR
AEC3	A.E. Crookes Park Scorers Booth	140 LAKEFRONT PROMENADE	REC-BNKSTR
AHP1	Applewood Heights Outdoor Pool	3119 CONSTITUTION BLVD	ODPOOL
BC1	Britannia Church	5961 HURONTARIO ST	MUSEUM-HER
BCC1	Burnhamthorpe Community Centre & Arena	1500 GULLEDEN DR	REC-MAJOR
BCC2	Burnhamthorpe CC Parks Bunker/Change House	1500 GULLEDEN DR	REC-MINOR
BCC3	Burnhamthorpe CC Covered Outdoor Rink	1500 GULLEDEN DR	REC-MAJOR
BE1	Benares Estate House-Heritage Designation	1503 CLARKSON RD N	MUSEUM-HER
BE2	Benares Estate Visitor Centre On Heritage Designated Land	1507 CLARKSON RD N	MUSEUM-HER
BE3	Benares Estate Barn/Stable-Heritage Designation	1503 CLARKSON RD N	MUSEUM-HER
BE4	Benares Estate Dairy Building Ice House-Heritage Designation	1504 CLARKSON RD N	MUSEUM-HER
BE5	Benares Estate Potting Shed-Heritage Designation	1505 CLARKSON RD N	MUSEUM-HER
BE6	Benares Estate Baking House-Heritage Designation	1506 CLARKSON RD N	MUSEUM-HER
BGC1	Braeben Golf Course Club House-Heritage Listed	5700 TERRY FOX WAY	REC-MAJOR
BGC2	Braeben Golf Course Academy-Heritage Listed	5650 TERRY FOX WAY	REC-MINOR
BGC3	Braeben Golf Course Maintenance Building-Heritage Listed	5750 TERRY FOX WAY	REC-MINOR
BGC4	Braeben Golf Course Ball Shack-Heritage listed	5650 TERRY FOX WAY	REC-MINOR
BL1	Burnhamthorpe Library & Maja Prentice Theatre-DBNC-Heritage	3650 DIXIE RD	LIBRARY
BP1	Brookmede Centre	2264 COUNCIL RING RD	REC-MINOR
BRT1	Mississauga Transitway: Central Parkway Station-North (westbound)	4327 CENTRAL PKWY E	TRANSIT
BRT10	Mississauga Transitway: Tahoe Blvd Station-East (eastbound)	4653 TAHOE BLVD	TRANSIT
BRT11	Mississauga Transitway: Etobicoke Creek Station	1915 EGLINTON AVE E	TRANSIT
BRT12	Mississauga Transitway: Spectrum Way Station-South (eastbound)	5005 SPECTRUM WAY	TRANSIT
BRT13	Mississauga Transitway: Spectrum Way Station-North (westbound)	5007 SPECTRUM WAY	TRANSIT

BRT14	Mississauga Transitway: Orbitor Drive Station-South (eastbound)	5015 ORBITOR DR	TRANSIT
BRT15	Mississauga Transitway: Orbitor Drive Station-North (westbound)	5017 ORBITOR DR	TRANSIT
BRT16	Mississauga Transitway: Renforth Drive Station	5001 COMMERCE BLVD	TRANSIT
BRT17	Mississauga Transitway: Erin Mills Station-North (westbound)	4430 ERIN MILLS PKWY	TRANSIT
BRT18	Mississauga Transitway: Erin Mills Station-South (eastbound)	4380 ERIN MILLS PKWY	TRANSIT
BRT19	Mississauga Transitway: Erin Mills Station-Service Building	4381 ERIN MILLS PKWY	TRANSIT
BRT2	Mississauga Transitway: Central Parkway Station-South (eastbound)	4325 CENTRAL PKWY E	TRANSIT
BRT20	Mississauga Transitway: Winston Churchill Station-North (westbound)	4334 WINSTON CHURCHILL BLVD	TRANSIT
BRT21	Mississauga Transitway: Winston Churchill Station-South (eastbound)	4300 WINSTON CHURCHILL BLVD	TRANSIT
BRT22	Mississauga Transitway: Winston Churchill Station-Service Building	4301 WINSTON CHURCHILL BLVD	TRANSIT
BRT3	Mississauga Transitway: Cawthra Rd Station-North (westbound)	775 EASTGATE PKWY	TRANSIT
BRT4	Mississauga Transitway: Cawthra Rd Station-South (eastbound)	776 EASTGATE PKWY	TRANSIT
BRT5	Mississauga Transitway: Tomken Rd Station-North (westbound)	4452 TOMKEN RD	TRANSIT
BRT6	Mississauga Transitway: Tomken Rd Station-South (eastbound)	4450 TOMKEN RD	TRANSIT
BRT7	Mississauga Transitway: Dixie Rd Station-North (Westbound)	4442 DIXIE RD MISSISSAUGA ON	TRANSIT
BRT8	Mississauga Transitway: Dixie Rd St-South (eastbound)	4440 DIXIE RD MISSISSAUGA ON	TRANSIT
BRT9	Mississauga Transitway: Tahoe Blvd Station-West (westbound)	4651 TAHOE BLVD MISSISSAUGA ON	TRANSIT
BWP1	Birchwood Park Comfort Station	1547 LAKESHORE RD W MISSISSAUGA ON	COMSTA
BYP1	Brickyard Park Electrical Bunker	3061 CLAYHILL RD MISSISSAUGA ON	PRK-BNKSTR
BYP2	Brickyard Park Comfort Station & Parks Bunker	3061 CLAYHILL RD MISSISSAUGA ON	COMSTA
CAF1	Courtneypark Athletic Field Comfort Station & Parks Bunker	600 COURTNEY PARK DR W MISSISSAUGA ON	COMSTA
CAW1	Carmen Corbasson/Cawthra Community Centre & Arena	1399 CAWTHRA RD MISSISSAUGA ON	REC-MAJOR
CAW2	Mississauga Senior Citizens Centre	1389 CAWTHRA RD MISSISSAUGA ON	REC-MINOR
CAW3	Port Credit Lawn Bowling Club	1375 CAWTHRA RD MISSISSAUGA ON	REC-MINOR
CCC1	Community Common Comfort Station	355 PRINCESS ROYAL DR MISSISSAUGA ON	COMSTA
CCP1	Century City Park Gazebo	933 FOCAL RD MISSISSAUGA ON	L5V SHELTER
CD1	Clarkson Depot Main Building	2167 ROYAL WINDSOR DR MISSISSAUGA ON	WRKPRK-DEP
CD2	Clarkson Depot Dome-1 (east)	2167 ROYAL WINDSOR DR MISSISSAUGA ON	WRK-STORAG
CD3	Clarkson Depot Operational Hub	2167 ROYAL WINDSOR DR MISSISSAUGA ON	WRKPRK-DEP
CD4	Clarkson Depot Fabric Dome-2 (west)	2167 ROYAL WINDSOR DR MISSISSAUGA ON	WRK-STORAG
CD5	Clarkson Depot Storage Building East	2167 ROYAL WINDSOR DR MISSISSAUGA ON	WRK-STORAG
CD6	Clarkson Depot Storage Building West	2167 ROYAL WINDSOR DR MISSISSAUGA ON	WRK-STORAG
CE1	Riverwood-Chappell Estate House/ Parker Estate-Heritage Designation	4300 RIVERWOOD PARK LANE MISSISSAUGA ON	PARK-OTHER
CE2	Riverwood-Chappell Estate/ Parker Estate Carport-Heritage Designation	4300 RIVERWOOD PARK LANE MISSISSAUGA ON	PARK-OTHER
CEE1	Cawthra Elliott Estate House-Heritage Designation	1507 CAWTHRA RD MISSISSAUGA ON	REC-MINOR

CHC1	Churchill Meadows Community Centre & Pool	5320 NINTH LINE MISSISSAUGA ON	REC-MAJOR
CL1	Cooksville Library in Cooksville Colonnade-Leased	3024 HURONTARIO ST MISSISSAUGA	LIBRARY
CLK1	Clarkson Community Centre Pool Arena & Library	2475 TRUSCOTT DR MISSISSAUGA O	REC-MAJOR
CMC1	Churchill Meadows Common Comfort Station	3370 MCDOWELL DR MISSISSAUGA	COMSTA
CMC2	Churchill Meadows Common Park Gazebo	3370 MCDOWELL DR MISSISSAUGA	SHELTER
CMH1	Clarke Memorial Hall-Heritage Designation	161 LAKESHORE RD W MISSISSAUGA	REC-MINOR
CML1	Churchill Meadows Branch Library & Activity Centre	3801 THOMAS ST MISSISSAUGA ON	LIBRARY
CPL1	Courtneypark Library	730 COURTNEYPARK DR W MISSISSA	LIBRARY
CPP1	Cawthra Park Pool	1305 CAWTHRA RD MISSISSAUGA O	REC-MAJOR
CSP1	Clarkson Pool(NOT IN USE)	2524 BROMSGROVE RD MISSISSAUG	REC-MAJOR
CT1	Camp Totoredaca Building A (SMALL CABIN)	2715 MEADOWVALE BLVD MISSISSA	REC-MINOR
CT2	Camp Totoredaca Building B (LARGE CABIN)	2715 MEADOWVALE BLVD MISSISSA	REC-MINOR
CT3	Camp Totoredaca Hut-1 Nurses Hut	2715 MEADOWVALE BLVD MISSISSA	REC-MINOR
CT4	Camp Totoredaca Hut-2 Chief's Hut	2715 MEADOWVALE BLVD MISSISSA	REC-MINOR
CVM1	Credit Village Marina-Heritage Listed	12 STAVEBANK RD S MISSISSAUGA C	PARK-OTHER
DAF1	Dunton Athletic Field Comfort Station	6180 KENNEDY RD MISSISSAUGA ON	COMSTA
DAF2	Dunton Athletic Field Picnic Shelter East	6180 KENNEDY RD MISSISSAUGA ON	SHELTER
DAF3	Dunton Athletic Field Picnic Shelter West	6180 KENNEDY RD MISSISSAUGA ON	SHELTER
DAF4	Dunton Athletic Field Parks Bunker (not FPM)	6180 KENNEDY RD MISSISSAUGA ON	PRK-BNKSTR
DAF5	Dunton Athletic Field Electrical Bunker	6180 KENNEDY RD MISSISSAUGA ON	PRK-BNKSTR
DKP1	Douglas Kennedy-Tenth Inning Concession Stand-Heritage Listed	810 LAKEFRONT PROMENADE MISSI	REC-MINOR
DMD1	Dr. Martin Dobkin Park Comfort Station & Parks Bunker	395 FAIRVIEW RD W MISSISSAUGA C	COMSTA
DRC1	Don Rowing Club-Heritage Listed	25 FRONT ST N MISSISSAUGA ON L5	REC-MINOR
DRP1	David Ramsey Outdoor Pool	2470 THORN LODGE DR MISSISSAUG	ODPOOL
DUC1	Dixie Union Chapel - Heritage Listed	707 DUNDAS ST E MISSISSAUGA ON	MUSEUM-HER
ECH1	Erindale Community Hall-Heritage Designation	1620 DUNDAS ST W MISSISSAUGA O	REC-MINOR
EMA1	Erin Mills Twin Arena	3205 UNITY DR MISSISSAUGA ON L5	REC-MAJOR
EMA2	Erin Mills Twin Arena Parks Bunker (not FPM)	3205 UNITY DR MISSISSAUGA ON L5	PRK-BNKSTR
EMC1	Erin Meadows Community Centre Pool & Library	2800 ERIN CENTRE BLVD MISSISSAU	REC-MAJOR
EP1	Erindale Park Comfort Station & Parks Bunker - Heritage Listed	1695 DUNDAS ST W MISSISSAUGA O	COMSTA
EP2	Erindale Park Parks Bunker (not FPM)	1695 DUNDAS ST W MISSISSAUGA O	PRK-BNKSTR
EP3	Erindale Park Picnic Shelter-Heritage Listed	1695 DUNDAS ST W MISSISSAUGA O	SHELTER
FBP1	Fallingbrook Park Comfort Station	5135 FALLINGBROOK DR MISSISSAU	COMSTA
FCC1	Fire - 911 Call Centre Brampton	7750 HURONTARIO ST BRAMPTON C	FIRE
FMC1	Frank McKechnie Community Centre Library & Pool	310 BRISTOL RD E MISSISSAUGA ON	REC-MAJOR

FMC2	Frank McKecknie CC Picnic Shelter	310 BRISTOL RD E MISSISSAUGA ON	SHELTER
FP1	Fleetwood Park Comfort Station	2000 BURNHAMTHORPE RD E MISSISSAUGA ON	COMSTA
FS01	Fire Station 101 (HQ)	15 FAIRVIEW RD W MISSISSAUGA ON	FIRE
FS02	Fire Station 102 (Lakeview)	710 THIRD ST MISSISSAUGA ON	FIRE
FS03	Fire Station 103 (Clarkson)	2035 LUSHES AVE MISSISSAUGA ON	FIRE
FS04	Fire Station 104 (Port Credit)-Heritage Designation	62 PORT ST W MISSISSAUGA ON	FIRE
FS05	Fire Station 105 (Malton East)	7101 GOREWAY DR MISSISSAUGA ON	FIRE
FS06	Fire Station 106 (Winding Trail)	1355 WINDING TR MISSISSAUGA ON	FIRE
FS061	Fire Station 106 Storage/Garbage Building	1355 WINDING TR MISSISSAUGA ON	FIRE
FS07	Fire Station 107 (Erindale)	1965 DUNDAS ST W MISSISSAUGA ON	FIRE
FS08	Fire Station 108 (Streetsville)	2267 BRITANNIA RD W MISSISSAUGA ON	FIRE
FS09	Fire Station 109 (Fire Hall/Training)	1735 BRITANNIA RD E MISSISSAUGA ON	FIRE
FS091	Fire Station 109 Training Tower	1735 BRITANNIA RD E MISSISSAUGA ON	FIRE
FS092	Fire Station 109 Fire House	1735 BRITANNIA RD E MISSISSAUGA ON	FIRE
FS093	Fire Station 109 Portable 1	1735 BRITANNIA RD E MISSISSAUGA ON	FIRE
FS094	Fire Station 109 Portable 2	1735 BRITANNIA RD E MISSISSAUGA ON	FIRE
FS10	Fire Station 110 (Queensway)	2316 HURONTARIO ST MISSISSAUGA ON	FIRE
FS11	Fire Station 111 (Meadowvale)	2740 DERRY RD W MISSISSAUGA ON	FIRE
FS12	Fire Station 112 (Creditview)	4090 CREDITVIEW RD MISSISSAUGA ON	FIRE
FS14	Fire Station 114 (Heartland)	5845 FALBOURNE ST MISSISSAUGA ON	FIRE
FS15	Fire Station 115 (Erin Mills)	4595 GLEN ERIN DR MISSISSAUGA ON	FIRE
FS16	Fire Station 116 (Malton West) & Peel Ambulance Reporting Centre	6825 TOMKEN RD MISSISSAUGA ON	FIRE
FS17	Fire Station 117 (North Dixie)	1090 NUVIK CRT MISSISSAUGA ON	FIRE
FS18	Fire Station 118 (East Credit)	1045 BRISTOL RD W MISSISSAUGA ON	FIRE
FS19	Fire Station 119 (Airport) & ROP Station S11	6375 AIRPORT RD MISSISSAUGA ON	FIRE
FS20	Fire Station 120	125 EGLINTON AVE W MISSISSAUGA ON	FIRE
FS21	Fire Station 121 (Meadowvale Village)	6745 MAVIS RD MISSISSAUGA ON	FIRE
FS22	Fire Station 122 (Churchill Meadows)	3600 THOMAS ST MISSISSAUGA ON	FIRE
GMC1	Garry W. Morden Fire Training Centre	7535 NINTH LINE MISSISSAUGA ON	FIRE
GMC2	Garry W. Morden Fire Training Centre Smoke Tower	7535 NINTH LINE MISSISSAUGA ON	FIRE
GMC3	Garry W. Morden Fire Training Centre Field Shelter	7535 NINTH LINE MISSISSAUGA ON	FIRE
GMC4	Garry W. Morden Fire Training Centre Burn Building	7535 NINTH LINE MISSISSAUGA ON	FIRE
GMC5	Garry W. Morden Fire Training Centre Storage Building	7535 NINTH LINE MISSISSAUGA ON	FIRE
GMC6	Garry W. Morden Fire Training Centre Track Observation Tower	7535 NINTH LINE MISSISSAUGA ON	FIRE
GP1	Garnetwood Park Comfort Station	1996 RATHBURN RD E MISSISSAUGA ON	COMSTA

GSP1	Glenforest Pool		3575 FIELDGATE DR	MISSISSAUGA ON	REC-MAJOR
HAN1	Hancock Woodlands Greenhouses Header Building-Heritage Listed		2151 CAMILLA RD	MISSISSAUGA ON	PARK-OTHER
HAN2	Hancock Woodlands Greenhouse 1-Heritage Listed		2151 CAMILLA RD	MISSISSAUGA ON	PARK-OTHER
HAN3	Hancock Woodlands Greenhouse 2-Heritage Listed		2151 CAMILLA RD	MISSISSAUGA ON	PARK-OTHER
HAN4	Hancock Woodlands Greenhouse 3-Heritage Listed		2151 CAMILLA RD	MISSISSAUGA ON	PARK-OTHER
HAN5	Hancock Woodlands Office Building-Heritage Listed(under review)		2151 CAMILLA RD	MISSISSAUGA ON	PARK-OTHER
HF1	Harris Farm Main House- heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF10	Harris Farm Pump House-Not In Use-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF11	Harris Farm Silo-not in use-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF2	Harris Farm Small Coverall-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF3	Harris Farm Greenhouse Shed-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF4	Harris Farm Biege Coverall-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF5	Harris Farm Green Steel Shed-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF6	Harris Farm Green Coverall-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF7	Harris Farm Garage & Loft-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HF8	Harris Farm Smoke/Ice Hut-heritage listed		6545 CREDITVIEW RD	MISSISSAUGA ON	PARK-OTHER
HKP1	Harold E Kennedy Park Shelter		20 ROSEWOOD AVE	MISSISSAUGA ON	SHELTER
HMR1	Hyde Mill Ruins-Heritage Designation		56 ONTARIO ST E	MISSISSAUGA ON	CULT-OTHER
HP1	Huron Park Community Centre Pool & Arena		830 PAISLEY BLVD W	MISSISSAUGA ON	REC-MAJOR
HP2	Huron Park Parks Bunker Main		830 PAISLEY BLVD W	MISSISSAUGA ON	PRK-BNKSTR
HP3	Huron Park Electrical Bunker		830 PAISLEY BLVD W	MISSISSAUGA ON	PRK-BNKSTR
HP4	Huron Park Credit Valley Tennis Club		830 PAISLEY BLVD W	MISSISSAUGA ON	REC-MINOR
HP5	Huron Park Picnic Shelter		830 PAISLEY BLVD W	MISSISSAUGA ON	SHELTER
HP6	Huron Park Prefab Parks Bunker (not FPM)		830 PAISLEY BLVD W	MISSISSAUGA ON	PRK-BNKSTR
HP7	Huron Park Credit Valley Tennis Club Storage Shed		830 PAISLEY BLVD W	MISSISSAUGA ON	REC-BNKSTR
HWE1	Harding Waterfront Estate: Bell-Gairdner House- Heritage Designation		2700 LAKESHORE RD W	MISSISSAUGA ON	REC-MINOR
HWE2	Harding Waterfront Estate: Coach House-Heritage Designation		2682 LAKESHORE RD W	MISSISSAUGA ON	REC-MINOR
HWE3	Harding Waterfront Estate: Garage-Heritage Designation		2700 LAKESHORE RD W	MISSISSAUGA ON	REC-MINOR
IA1	Iceland Arena		705 MATHESON BLVD E	MISSISSAUGA ON	REC-MAJOR
IA2	Iceland Arena & Sports Park Electrical Bunker		705 MATHESON BLVD E	MISSISSAUGA ON	PRK-BNKSTR
IA3	Iceland Arena & Sports Park Park Bunker (not FPM)		705 MATHESON BLVD E	MISSISSAUGA ON	PRK-BNKSTR
IA4	Iceland Arena & Sports Park Gazebo		705 MATHESON BLVD E	MISSISSAUGA ON	SHELTER
JCS1	JC Saddlington Park Comfort Station-Heritage Designation		53 LAKE ST	MISSISSAUGA ON	COMSTA
JCS2	JC Saddlington Park Pump House/ Port Credit Old Pumping Station		53 LAKE ST	MISSISSAUGA ON	PRK-BNKSTR
JCS3	JC Saddlington Park/ Port Credit Old Pumping Station Garage-Heritage Listed		53 LAKE ST	MISSISSAUGA ON	PRK-BNKSTR

JCS4	JC Saddington Park Water Storage Tank- Not In Use-Heritage Listed	53 LAKE ST MISSISSAUGA ON	PRK-BNKSTR
JCS5	JC Saddington Park Pavilion-Heritage Designation	53 LAKE ST MISSISSAUGA ON	SHELTER
JDP1	Jack Darling Park Comfort Station East	1180 LAKESHORE RD W MISSISSAUGA ON	COMSTA
JDP2	Jack Darling Park Comfort Station West	1180 LAKESHORE RD W MISSISSAUGA ON	COMSTA
JDP3	Jack Darling Park Parks Bunker (not FPM)	1180 LAKESHORE RD W MISSISSAUGA ON	PRK-BNKSTR
JDP4	Jack Darling Park Picnic Shelter	1180 LAKESHORE RD W MISSISSAUGA ON	SHELTER
JDP5	Jack Darling Park Comfort Station North (leased)	1180 LAKESHORE RD W MISSISSAUGA ON	COMSTA
JJP1	J.J.Plause Park- Snug Harbour Restaurant Building	14 STAVEBANK RD S MISSISSAUGA ON	REC-MINOR
JMP1	Jim Murray Park Shelter	5225 TENTH LINE WEST MISSISSAUGA ON	SHELTER
KEN1	Applewood Tennis Club (Kennedy Park)	3505 GOLDEN ORCHARD DR MISSISSAUGA ON	REC-MINOR
KP1	Kariya Park Service Building North (not FPM)	3620 KARIYA DR MISSISSAUGA ON	PRK-BNKSTR
KP2	Kariya Park Service Building South(not FPM)	3620 KARIYA DR MISSISSAUGA ON	PRK-BNKSTR
KP3	Kariya Park Pavillion & Bell Cover Shelter-Heritage Listed	3620 KARIYA DR MISSISSAUGA ON	SHELTER
KP4	Kariya Park Mechanical Electrical Bunker-Heritage Listed	3620 KARIYA DR MISSISSAUGA ON	PRK-BNKSTR
LAC1	Living Arts Centre-Heritage Listed	4141 LIVING ARTS DR MISSISSAUGA ON	CIVIC-PREC
LAP1	Lake Aquatain Park Comfort Station West & Parks Bunker-Heritage Listed	2750 AQUITAINE AVE MISSISSAUGA ON	COMSTA
LAP2	Lake Aquatain Park-Comfort Station East-Heritage Listed	2750 AQUITAINE AVE MISSISSAUGA ON	COMSTA
LBM1	Bradley Museum-Heritage Designation	1620 ORR RD MISSISSAUGA ON	MUSEUM-HER
LBM2	Bradley Museum-The Anchorage-Heritage Designation	1610 ORR RD MISSISSAUGA ON	MUSEUM-HER
LBM3	Bradley Museum-Barn-Heritage Designation	1620 ORR RD MISSISSAUGA ON	MUSEUM-HER
LBM4	Bradley Museum-Log Cabin-Heritage Designation	1600 ORR RD MISSISSAUGA ON	MUSEUM-HER
LBM5	Bradley Museum-Wood Shed-Heritage Designation	1620 ORR RD MISSISSAUGA ON	MUSEUM-HER
LBM6	Bradley Museum-Outhouse - Heritage Designation	1620 ORR RD MISSISSAUGA ON	MUSEUM-HER
LBP1	Lewis Bradley Outdoor Pool-Heritage Listed	745 INVERHOUSE DR MISSISSAUGA ON	ODPOOL
LBP2	Lewis Bradley Park Barn (Parks Bunker)-Heritage Listed	2019 ORR RD MISSISSAUGA ON	PRK-BNKSTR
LCP1	Lions Club Of Credit Valley Outdoor Pool	20 ROSEWOOD AVE MISSISSAUGA ON	ODPOOL
LFP1	Lisgar Fields Park Parks Bunker (not FPM)	3805 DOUG LEAVENS BLVD MISSISSAUGA ON	PRK-BNKSTR
LFP2	Lisgar Fields Park Shelter (at splash pad)	3805 DOUG LEAVENS BLVD MISSISSAUGA ON	SHELTER
LFP3	Lisgar Fields Park Comfort Station & Parks Bunker	6735 LISGAR DR MISSISSAUGA ON	COMSTA
LGC1	Lakeview Golf Course Club House-Heritage Designation	1190 DIXIE RD MISSISSAUGA ON	REC-MAJOR
LGC2	Lakeview Golf Course Maintenance Building-On Heritage Designated List	1190 DIXIE RD MISSISSAUGA ON	REC-MINOR
LGC3	Lakeview Golf Course Greens Keeper House- Heritage Designated List	1392 DIXIE RD MISSISSAUGA ON	REC-MINOR
LGC4	Lakeview Golf Course Starters Shed-On Heritage Designated List	1190 DIXIE RD MISSISSAUGA ON	REC-MINOR
LGC5	Lakeview Golf Course Pumphouse-On Heritage Designated List	1190 DIXIE RD MISSISSAUGA ON	REC-MINOR
LGC6	Lakeview Golf Course Cart Storage Bldg-On Heritage Designated List	1190 DIXIE RD MISSISSAUGA ON	REC-MINOR

LGC7	Lakeview Golf Course Fuel Station Shelter-On Heritage Design	1190 DIXIE RD	MISSISSAUGA ON L5E	REC-BNKSTR
LGC8	Lakeview Golf Course Sign Shelter-On Heritage Designated Land	1190 DIXIE RD	MISSISSAUGA ON L5E	REC-MINOR
LL1	Lakeview Library	1110 ATWATER AVE	MISSISSAUGA ON	LIBRARY
LP1	Lakeview Park Picnic Shelter 1-Heritage Listed	8111 LAKEFRONT PROMENADE	MISSISSAUGA ON	SHELTER
LP2	Lakeview Park Picnic Shelter 2-Heritage Listed	8111 LAKEFRONT PROMENADE	MISSISSAUGA ON	SHELTER
LPC1	Lakeside Park Comfort Station & Parks Bunker	2268 LAKESHORE RD W	MISSISSAUGA ON	COMSTA
LPC2	Lakeside Park Irrigation Bunker	2268 LAKESHORE RD W	MISSISSAUGA ON	PRK-BNKSTR
LPC3	Lakeside Park Picnic Shelter East	2268 LAKESHORE RD W	MISSISSAUGA ON	SHELTER
LPC4	Lakeside Park Picnic Shelter West	2268 LAKESHORE RD W	MISSISSAUGA ON	SHELTER
LPH1	Lorne Park Hall	1288 LORNE PARK RD	MISSISSAUGA ON	REC-MINOR
LPL1	Lorne Park Library	1474 TRUSCOTT DR	MISSISSAUGA ON	LIBRARY
LPP1	Lakefront Promenade Parks Depot	725 LAKEFRONT PROMENADE	MISSISSAUGA ON	WRKPRK-DEP
LPP2	Lakefront Promenade Splashpad Comfort Station (at Douglas	155 LAKEFRONT PROMENADE	MISSISSAUGA ON	COMSTA
LPP3	Lakefront Promenade Marina & Comfort Station-Heritage Listed	135 LAKEFRONT PROMENADE	MISSISSAUGA ON	PARK-OTHER
LPP4	Lakefront Promenade Comfort Station (at A.E. Crookes Headland	1110 LAKEFRONT PROMENADE	MISSISSAUGA ON	COMSTA
LPP5	Lakefront Promenade Picnic Shelter (at A.E. Crookes Headland	95 LAKEFRONT PROMENADE	MISSISSAUGA ON	SHELTER
LPP6	Lakefront Promenade- Comfort Station (@ RK McMillan Head	830 AVIATION RD	MISSISSAUGA ON	COMSTA
MAD1	Malton Depot Main Building	7100 FIR TREE DR	MISSISSAUGA ON	WRKPRK-DEP
MAD2	Malton Depot Dome-1 (south)	7100 FIR TREE DR	MISSISSAUGA ON	WRK-STORAG
MAD3	Malton Depot Dome-2 (north)	7100 FIR TREE DR	MISSISSAUGA ON	WRK-STORAG
MAD4	Malton Depot Operational Hub	7100 FIR TREE DR	MISSISSAUGA ON	WRKPRK-DEP
MAD5	Malton Depot Garage	7100 FIR TREE DR	MISSISSAUGA ON	WRK-STORAG
MAD6	Malton Depot Storage 1 (North)	7100 FIR TREE DR	MISSISSAUGA ON	WRK-STORAG
MAD7	Malton Depot Storage 2 (South)	7100 FIR TREE DR	MISSISSAUGA ON	WRK-STORAG
MAH1	Malton Hall(Victory)-Heritage Listed	3091 VICTORY CRES	MISSISSAUGA ON	REC-MINOR
MAL1	Malton Community Centre Pool & Library	3540 MORNING STAR DR	MISSISSAUGA ON	REC-MAJOR
MAL2	Malton CC Parks Bunker (not FPM)	3540 MORNING STAR DR	MISSISSAUGA ON	PRK-BNKSTR
1-Mar	Front Street Pumping Station/Port Credit Light House/BIA/Com	105 LAKESHORE RD W	MISSISSAUGA ON	COMSTA
2-Mar	Marina Park Comfort Station Old-Heritage Designation	21 FRONT ST S	MISSISSAUGA ON	COMSTA
3-Mar	Marina Park Fish Grinding Station/Shelter-Heritage Designation	21 FRONT ST S	MISSISSAUGA ON	SHELTER
MC1	Mount Charles Park Comfort Station (Under Construction)	1265 CARDIFF BLVD	MISSISSAUGA ON	COMSTA
MCA1	Meadowvale Conservation Area Comfort Station	1081 OLD DERRY RD	MISSISSAUGA ON	COMSTA
MCA3	Meadowvale Conservation Area Picnic Shelter A	1081 OLD DERRY RD	MISSISSAUGA ON	SHELTER
MCA4	Meadowvale Conservation Area Picnic Shelter B	1081 OLD DERRY RD	MISSISSAUGA ON	SHELTER
MCA5	Meadowvale Conservation Area Sign Shelter	1081 OLD DERRY RD	MISSISSAUGA ON	PRK-BNKSTR

MCC1	Mississauga Canoe Club-Heritage Listed	31 FRONT ST N MISSISSAUGA ON L5	REC-MINOR
MCH1	Mississauga City Hall (Civic Centre)-Heritage Listed	300 CITY CENTRE DR MISSISSAUGA ON L5	CIVIC-PREC
MCH2	Mississauga City Hall Day Care Storage Building-Heritage Listed	300 CITY CENTRE DR MISSISSAUGA ON L5	CIVIC-PREC
MCH3	201 City Centre Drive- City Hall Satellite Offices-Leased	201 CITY CENTRE DR MISSISSAUGA ON L5	CORP
MCL1	Mississauga Central Library-Heritage Listed	301 BURNHAMTHORPE RD W MISSISSAUGA ON L5	CIVIC-PREC
MCP1	Malton Community Pool (NOT IN USE)	3545 MORNING STAR DR MISSISSAUGA ON L5	REC-MAJOR
MCT1	Meadowvale Theatre	6315 MONTEVIDEO RD MISSISSAUGA ON L5	THEATRE
MDC1	Malton Day Care Centre	3500 MORNING STAR DR MISSISSAUGA ON L5	REC-MINOR
MDC2	Malton Day Care Storage Building	3500 MORNING STAR DR MISSISSAUGA ON L5	REC-BNKSTR
MDV1	Meadowvale Community Centre Pool & Library	6655 GLEN ERIN DR MISSISSAUGA ON L5	REC-MAJOR
MDV2	Meadowvale CC Exterior Shade Structure	6655 GLEN ERIN DR MISSISSAUGA ON L5	PRK-BNKSTR
ME1	Riverwood-MacEwan Estate House-Heritage Designation	4190 RIVERWOOD PARK LANE MISSISSAUGA ON L5	PARK-OTHER
ME2	Riverwood-MacEwan Estate Barn-Heritage Designation	4150 RIVERWOOD PARK LANE MISSISSAUGA ON L5	PRK-BNKSTR
ME3	Riverwood-MacEwan Estate Parks Maintenance Bunker- On Hold	4150 RIVERWOOD PARK LANE MISSISSAUGA ON L5	PRK-BNKSTR
MED1	Meadowvale Depot Main Building	6300 MILLCREEK DR MISSISSAUGA ON L5	WRKPRK-DEP
MED2	Meadowvale Depot Dome-1 (East)	6300 MILLCREEK DR MISSISSAUGA ON L5	WRK-STORAG
MED3	Meadowvale Depot Dome-2 (West)	6300 MILLCREEK DR MISSISSAUGA ON L5	WRK-STORAG
MED4	Meadowvale Depot Operational hub	6300 MILLCREEK DR MISSISSAUGA ON L5	WRKPRK-DEP
MED5	Meadowvale Depot Storage Building	6300 MILLCREEK DR MISSISSAUGA ON L5	WRK-STORAG
MEH1	Meadowvale Hall-Heritage Designation	6970 SECOND LINE WEST MISSISSAUGA ON L5	REC-MINOR
MFH1	Mary Fix House-Heritage Designation	25 PINETREE WAY MISSISSAUGA ON L5	REC-RESID
MFR1	Meadowvale Four Rinks (Arena)	2160 TORQUAY MEWS MISSISSAUGA ON L5	REC-MAJOR
MFR2	Meadowvale Four Rinks Hydro Vault	2160 TORQUAY MEWS MISSISSAUGA ON L5	REC-BNKSTR
MN1	Mavis North Main Building	3235 MAVIS RD MISSISSAUGA ON L5	WRKPRK-DEP
MN2	Mavis North Storage Building(NOT FPM MAINTAINED)	3235 MAVIS RD MISSISSAUGA ON L5	WRK-STORAG
MN3	Mavis North Greenhouse Shed(NOT FPM MAINTAINED)	3235 MAVIS RD MISSISSAUGA ON L5	WRK-STORAG
MN4	Mavis North Warehouse	3235 MAVIS RD MISSISSAUGA ON L5	WRK-STORAG
MP1	Meadowwood Park Tennis Club Storage Building	484 APPLE LANE MISSISSAUGA ON L5	REC-MINOR
MS1	Mavis South Main Building	3185 MAVIS RD MISSISSAUGA ON L5	WRKPRK-DEP
MS10	Mavis South Carpentry Shop (Lightbody) Storage Building	3185 MAVIS RD MISSISSAUGA ON L5	WRK-STORAG
MS2	Mavis South Small Engine Repair	3185 MAVIS RD MISSISSAUGA ON L5	WRKPRK-DEP
MS3	Mavis South Dome-1 (North)	3185 MAVIS RD MISSISSAUGA ON L5	WRK-STORAG
MS4	Mavis South Carpentry Shop (Lightbody)	3185 MAVIS RD MISSISSAUGA ON L5	WRKPRK-DEP
MS5	Mavis South Operational Hub	3185 MAVIS RD MISSISSAUGA ON L5	WRKPRK-DEP
MS6	Mavis South Dome-2 (South)	3185 MAVIS RD MISSISSAUGA ON L5	WRK-STORAG

MS7	Mavis South Storage Building	3185 MAVIS RD	MISSISSAUGA ON L5	WRK-STORAG
MS8	Mavis South Recycling Building	3185 MAVIS RD	MISSISSAUGA ON L5	WRK-STORAG
MS9	Mavis South Modular Office	3185 MAVIS RD	MISSISSAUGA ON L5	WRKPRK-DEP
MSC1	Mississauga Sailing Club-Heritage Listed	120 LAKEFRONT PROMENADE	MISSISSAUGA ON L5	REC-MINOR
MSC2	Mississauga Sailing Club Garage-Heritage Listed	120 LAKEFRONT PROMENADE	MISSISSAUGA ON L5	REC-BNKSTR
MSP1	Meadowvale Sports Park Comfort Station	2255 MEADOWVALE BLVD	MISSISSAUGA ON L5	COMSTA
MSP2	Meadowvale Sports Park Parks Bunker (not FPM)	2255 MEADOWVALE BLVD	MISSISSAUGA ON L5	PRK-BNKSTR
MST1	Malton Satellite Terminal	6780 PROFESSIONAL CRT	MISSISSAUGA ON L5	TRANSIT
MST2	Malton Satellite Terminal-Canopy	6780 PROFESSIONAL CRT	MISSISSAUGA ON L5	TRANSIT
MTC1	Meadowvale Town Centre Transit Washroom (leased)	6677 MEADOWVALE TOWN CENTRE	MISSISSAUGA ON L5	TRANSIT
MV1	Mississauga Valley Community Centre Library Pool & Arena	1275 MISSISSAUGA VALLEY BLVD	MISSISSAUGA ON L5	REC-MAJOR
MV2	Mississauga Valley Gymnasium	1395 MISSISSAUGA VALLEY BLVD	MISSISSAUGA ON L5	REC-MAJOR
MV3	Mississauga Valley Park Parks Bunker Old	1385 MISSISSAUGA VALLEY BLVD	MISSISSAUGA ON L5	PRK-BNKSTR
MV4	Mississauga Valley Park Parks Bunker New	1385 MISSISSAUGA VALLEY BLVD	MISSISSAUGA ON L5	PRK-BNKSTR
MV5	Mississauga Valley Park Comfort Station	1385 MISSISSAUGA VALLEY BLVD	MISSISSAUGA ON L5	COMSTA
MV6	Mississauga Valley Park Picnic Shelter A	1385 MISSISSAUGA VALLEY BLVD	MISSISSAUGA ON L5	SHELTER
MV7	Mississauga Valley Park Picnic Shelter B	1275 MISSISSAUGA VALLEY BLVD	MISSISSAUGA ON L5	SHELTER
MVP1	Malton Village Park Gazebo	39 BEVERLEY ST	MISSISSAUGA ON L4	SHELTER
MWP1	Max Ward Park Parks Bunker- not FPM	2380 MATHESON BLVD E	MISSISSAUGA ON L4	PRK-BNKSTR
NIN1	Bussell House - Heritage Designation	7420 NINTH LINE	MISSISSAUGA ON L4	CULT-OTHER
NIN2	Trafalgar House - Heritage Listed- 7238 Ninth Line (Burned-To-Top)	7238 NINTH LINE	MISSISSAUGA ON L4	PARK-OTHER
NLP1	Ninth Line Sports Park Parks Bunker-not FPM	3115 NINTH LINE	MISSISSAUGA ON L4	PRK-BNKSTR
OCJ1	Ontario Court of Justice (950 Burnhamthorpe)	950 BURNHAMTHORPE RD W	MISSISSAUGA ON L4	CORP
OFS1	Old Fire Hall Streetsville-Heritage Listed	180 BROADWAY ST	MISSISSAUGA ON L4	CULT-OTHER
OP1	O'Connor Park Gazebo	3570 BALA DR	MISSISSAUGA ON L5N	SHELTER
PCA1	Port Credit Arena-Heritage Designation	40 STAVEBANK RD	MISSISSAUGA ON L5N	REC-MAJOR
PCL1	Port Credit Library-Heritage Listed	20 LAKESHORE RD E	MISSISSAUGA ON L5N	LIBRARY
PCM1	Port Credit Memorial Park Electrical Bunker-On Heritage Designation	32 STAVEBANK RD	MISSISSAUGA ON L5N	PRK-BNKSTR
PCM2	Port Credit Memorial Park Parks Bunker (not FPM)	32 STAVEBANK RD	MISSISSAUGA ON L5N	PRK-BNKSTR
PCM3	Port Credit Memorial Park Gazebo-Heritage Listed	32 STAVEBANK RD	MISSISSAUGA ON L5N	SHELTER
PCP1	Paul Coffey Arena-Heritage Listed	3430 DERRY RD E	MISSISSAUGA ON L5N	REC-MAJOR
PCP2	Paul Coffey Park Comfort Station Concession-Heritage Listed	3430 DERRY RD E	MISSISSAUGA ON L5N	COMSTA
PCP3	Paul Coffey Park Malton Tennis Club-Heritage Listed	3430 DERRY RD E	MISSISSAUGA ON L5N	REC-MINOR
PCP4	Paul Coffey Park Parks Bunker North (not FPM)	3430 DERRY RD E	MISSISSAUGA ON L5N	PRK-BNKSTR
PCP5	Paul Coffey Park Parks Bunker South (not FPM)	3430 DERRY RD E	MISSISSAUGA ON L5N	PRK-BNKSTR

PCP6	Paul Coffey Park Picnic Shelter North A-Heritage Listed	3430 DERRY RD E MISSISSAUGA ON	SHELTER
PCP7	Paul Coffey Park Picnic Shelter North B-Heritage Listed	3430 DERRY RD E MISSISSAUGA ON	SHELTER
PCP8	Paul Coffey Park Picnic Shelter South-Heritage Listed	3430 DERRY RD E MISSISSAUGA ON	SHELTER
PFF1	Paramount Fine Foods Centre - Main Bowl Arena	5500 ROSE CHERRY PL MISSISSAUGA	REC-MAJOR
PFF2	Paramount Fine Foods Centre - Community Rinks (Arena)	5500 ROSE CHERRY PL MISSISSAUGA	REC-MAJOR
PFF3	Paramount Fine Foods Centre - Fieldhouse	5600 ROSE CHERRY PL MISSISSAUGA	REC-MAJOR
PFF4	Paramount Fine Foods Centre - Outdoor Fields & Change House	5725 ROSE CHERRY PL MISSISSAUGA	COMSTA
PP1	Pinchin Property Leslie Log House-Heritage Designation	4415 MISSISSAUGA RD MISSISSAUGA	CULT-OTHER
PP5	Pinchin Property Steel Storage Shed (B1) On Heritage Designation	4415 MISSISSAUGA RD MISSISSAUGA	PARK-OTHER
QM2	Quenippenon Meadows Comfort Station & Parks Bunker	2625 ERIN CENTRE BLVD MISSISSAUGA	COMSTA
RBP1	Red Brush Park Parks Bunker (not FPM)	5139 RED BRUSH DR MISSISSAUGA ON	PRK-BNKSTR
RCC1	River Grove Community Centre & Pool	5800 RIVER GROVE AVE MISSISSAUGA	REC-MAJOR
RCC2	River Grove CC Parks Bunker (not FPM)	5800 RIVER GROVE AVE MISSISSAUGA	PRK-BNKSTR
RGP1	Brueckner Rhododendron Gardens Comfort Station & Parks Bunker	660 LAKESHORE RD W MISSISSAUGA	COMSTA
RLS1	Russell Langmaid School (Streetsville Cadets/Kendellhurst Academy)	170 CHURCH ST MISSISSAUGA ON L5	REC-MINOR
RMP1	Richards Memorial Park Comfort Station	804 LAKESHORE RD W MISSISSAUGA	COMSTA
RMIP2	Richards Memorial Park Picnic Shelter	804 LAKESHORE RD W MISSISSAUGA	SHELTER
RP1	Riverwood-Art Studio (Visual Arts Mississauga)-On Heritage Designation	4170 RIVERWOOD PARK LANE MISSISSAUGA	CULT-OTHER
SAL1	Small Arms Ltd Inspection Building - Heritage Designation	1352 LAKESHORE RD E MISSISSAUGA	CULT-OTHER
SBT1	City Centre Transit Terminal/ Square One Bus Terminal	200 RATHBURN RD W MISSISSAUGA	CORP
SC1	Semenyk Court T&W Admin	3484 SEMENYK CRT MISSISSAUGA ON	TRANSIT
SCC1	South Common Community Centre Pool & Library	2233 SOUTH MILLWAY MISSISSAUGA	REC-MAJOR
SCC2	South Common Park Parks Bunker (not FPM)	2233 SOUTH MILLWAY MISSISSAUGA	PRK-BNKSTR
SCC3	South Common Park Tennis Shelter (Erin Mills Tennis Club)	2233 SOUTH MILLWAY MISSISSAUGA	SHELTER
SCD1	Streetsville Cadet Centre (vacant)-On Heritage Designated Land	56 ONTARIO ST E MISSISSAUGA ON	PARK-OTHER
SCD2	Streetsville Cadet Centre Garage Building-On Heritage Designation	56 ONTARIO ST E MISSISSAUGA ON	PRK-BNKSTR
SCD3	Streetsville Cadet Centre- Silo Building on Hill-On Heritage Designation	56 ONTARIO ST E MISSISSAUGA ON	PARK-OTHER
SGP1	Sherwood Green Park Gazebo	1864 DEER'S WOLD MISSISSAUGA ON	SHELTER
SKH1	Streetsville Kinsmen Hall/ Old Grammar School-Heritage Designation	327 QUEEN ST S MISSISSAUGA ON L5	REC-MINOR
SL1	Streetsville Library-Heritage Listed	112 QUEEN ST S MISSISSAUGA ON L5	LIBRARY
SLP1	St. Lawrence Park Gazebo	75 ST. LAWRENCE DR MISSISSAUGA	SHELTER
SLP2	St. Lawrence Park Mechanical/Electrical Bunker	75 ST. LAWRENCE DR MISSISSAUGA	PRK-BNKSTR
SML1	Sheridan Mall Library	2225 ERIN MILLS PKY MISSISSAUGA	LIBRARY
SMP1	Streetsville Memorial Park Comfort Station & Concession-Heritage Listed	335 CHURCH ST MISSISSAUGA ON L5	REC-MINOR
SMP2	Streetsville Memorial Park Electrical Bunker-Heritage Listed	335 CHURCH ST MISSISSAUGA ON L5	PRK-BNKSTR

SMP3	Streetsville Memorial Park Old Water Treatment Building-Heritage	335 CHURCH ST MISSISSAUGA ON L5	PRK-BNKSTR
SOP1	Streetsville Outdoor Pool-Heritage Listed	335 CHURCH ST MISSISSAUGA ON L5	ODPOOL
SP1	Ron Lenyk Springfield Park Erindale Baseball Club House	3325 THE CREDIT WOODLANDS MISSISSAUGA ON L5	REC-MINOR
SP2	Ron Lenyk Springfield Park Tennis Club	3325 THE CREDIT WOODLANDS MISSISSAUGA ON L5	REC-MINOR
SP3	Ron Lenyk Springfield Park-Erindale Outdoor Pool	1244 SHAMIR CRES MISSISSAUGA ON L5	ODPOOL
SPC1	Streetsville Public Cemetary Parks Bunker (not FPM)	1786 BRISTOL RD W MISSISSAUGA ON L5	PRK-BNKSTR
SVH1	Streetsville Village Hall (B.I.A.) -Heritage Designation	280 QUEEN ST S MISSISSAUGA ON L5	REC-MINOR
TCP1	Tom Chater Memorial Park Club House	3195 THE COLLEGEWAY MISSISSAUGA ON L5	REC-MINOR
TCP2	Tom Chater Memorial Park Parks Bunker (not FPM)	3195 THE COLLEGEWAY MISSISSAUGA ON L5	PRK-BNKSTR
TCT1	Transit Central-Edward J. Dowling Transit Facility (Bldg ABCD)	975 CENTRAL PKY W MISSISSAUGA ON L5	TRANSIT
TCT2	Transit Central-Body Shop (Bldg F)	3585 ERINDALE STATION RD MISSISSAUGA ON L5	TRANSIT
TCT3	Transit Central-New Bus Storage Building (Bldg E)	3567 ERINDALE STATION RD MISSISSAUGA ON L5	TRANSIT
TCT4	Transit Central-Bldg ABCD Generator Bldg	975 CENTRAL PKY W MISSISSAUGA ON L5	TRANSIT
TCT5	Transit Central-Bldg E Generator Bldg	3567 ERINDALE STATION RD MISSISSAUGA ON L5	TRANSIT
TCT6	Transit Central-Bldg E Electrical Bldg	3567 ERINDALE STATION RD MISSISSAUGA ON L5	TRANSIT
TG1	The Grange/ Robinson-Adamson House-Heritage Designation	1921 DUNDAS ST W MISSISSAUGA ON L5	CULT-OTHER
TMP1	Tobias Mason Park Shelter (at splash pad)	3274 CACTUS GATE MISSISSAUGA ON L5	SHELTER
TTA1	Tomken Twin Arena	4495 TOMKEN RD MISSISSAUGA ON L5	REC-MAJOR
TTA2	Tomken Twin Arena Parks Bunker (not FPM)	4495 TOMKEN RD MISSISSAUGA ON L5	PRK-BNKSTR
UP1	Union Park Shelter	6627 TENTH LINE WEST MISSISSAUGA ON L5	SHELTER
VJA1	Vic Johnston Community Centre & Streetsville Arena-Heritage	335 CHURCH ST MISSISSAUGA ON L5	REC-MAJOR
WHP1	Woodhurst Heights Park Rink/Tennis and Change House	3475 ASH ROW CRES MISSISSAUGA ON L5	REC-MINOR
WL1	Woodlands Library	3255 ERINDALE STATION RD MISSISSAUGA ON L5	LIBRARY
WMT1	Westwood Mall Transit Building (Bus Terminal, Control Rm, Ldg)	3480 MORNING STAR DR MISSISSAUGA ON L5	TRANSIT
WOP1	Whiteoaks Park Tennis Club House	1608 BIRCHWOOD DR MISSISSAUGA ON L5	REC-MINOR
WPP1	Don McLean Westacres Outdoor Pool	2166 WESTFIELD DR MISSISSAUGA ON L5	ODPOOL
WPT1	Woodeden Park Tennis Shelter(Tecumseh Tennis Club)	1538 WOODDEDEN DR MISSISSAUGA ON L5	SHELTER

Appendix A4

CITY OF MISSISSAUGA

BAS SYSTEM ARCHITECTURES & COMMUNICATION PROTOCOLS

System Architectures

The new CoM BAS system architecture will be based on BacNet over IP controller technology using the project specified Network Cable (ie CAT 5/CAT6/CAT6E – Minimum CAT 5). The installing BAS contractor shall supply and install all necessary components of the BAS system including the Supervisory Controller(s) (SRPDC – JACE800) and any necessary switches/routers. The new facility BAS shall communicate to the Niagara N4 Supervisor using Fox Communication Protocol and shall communicate to all downstream field controllers using BacNet over IP. The CoM will provide a singular CoM IT network drop, all controller addressing shall be by the installing BAS contractor.

In some instances (where directed by CoM) connection to existing (non-obsolete) Legacy BAS systems already operating on either BacNet or LON network may be required. In those instances it may be applicable to retain existing 3-wire BacNet MS/TP or LON Networks. Approval from CoM is required in advance.

Connection to other OEMASC shall be via dedicated sub-networks using available open communication protocol of that systems (BacNet/IP, BacNET MSTP, LON, etc)

Description of system architecture is as follows:

- CoM IT Network to SRDPC (JACE 8000 Series Controller): 1-IP Drop using Specified Network Cable (ie CAT 5/CAT6/CAT6E)
- IT Network to dedicated managed switch/router: 1 IP Drop per managed switch using Specified Network Cable
- Dedicated BAS Managed Switch/Router to connect up-to four (4) BacNet-IP Subnetworks (per managed switch). Sub-networks can each handle up-to 20 IP Based field controllers (RPDC), daisy chained together in series using Specified Network Cable (ie CAT 5/CAT6/CAT6E)
- From RPDC to any Non-IP based Terminal Equipment controllers (TEC), install a new 3-wire MS/TP network from an RPDC connect multiple TEC in that same area of facility. (This only applies where BacNet IP terminal controllers are not available in the pre-approved Family of controllers – ie VAV Box controllers). **Contractors must identify this in their Bid Submission.**

- SRPDC (JACE) to be configured to manage the Sub-Network controller(s) using FOX Communication protocol. This limits the Niagara device count (for licensing) to one (1) per building.
- From the Sub-Network Controller(s) to RPDC the communication protocol shall be BacNet/IP.
- From RPDC to terminal equipment controllers (TEC) communication shall be BacNet IP or in certain instances BacNet MS/TP (see above).
- Connection to other OEMASC shall be a dedicated sub-network or via IP connection from OEMASC to CoM IT using available open communication protocol of that systems (BacNet/IP, BacNET MS/TP, LON, etc)

Refer to Drawing SK-2 Attached

EMCS Cabinet Expectations

Acceptable:

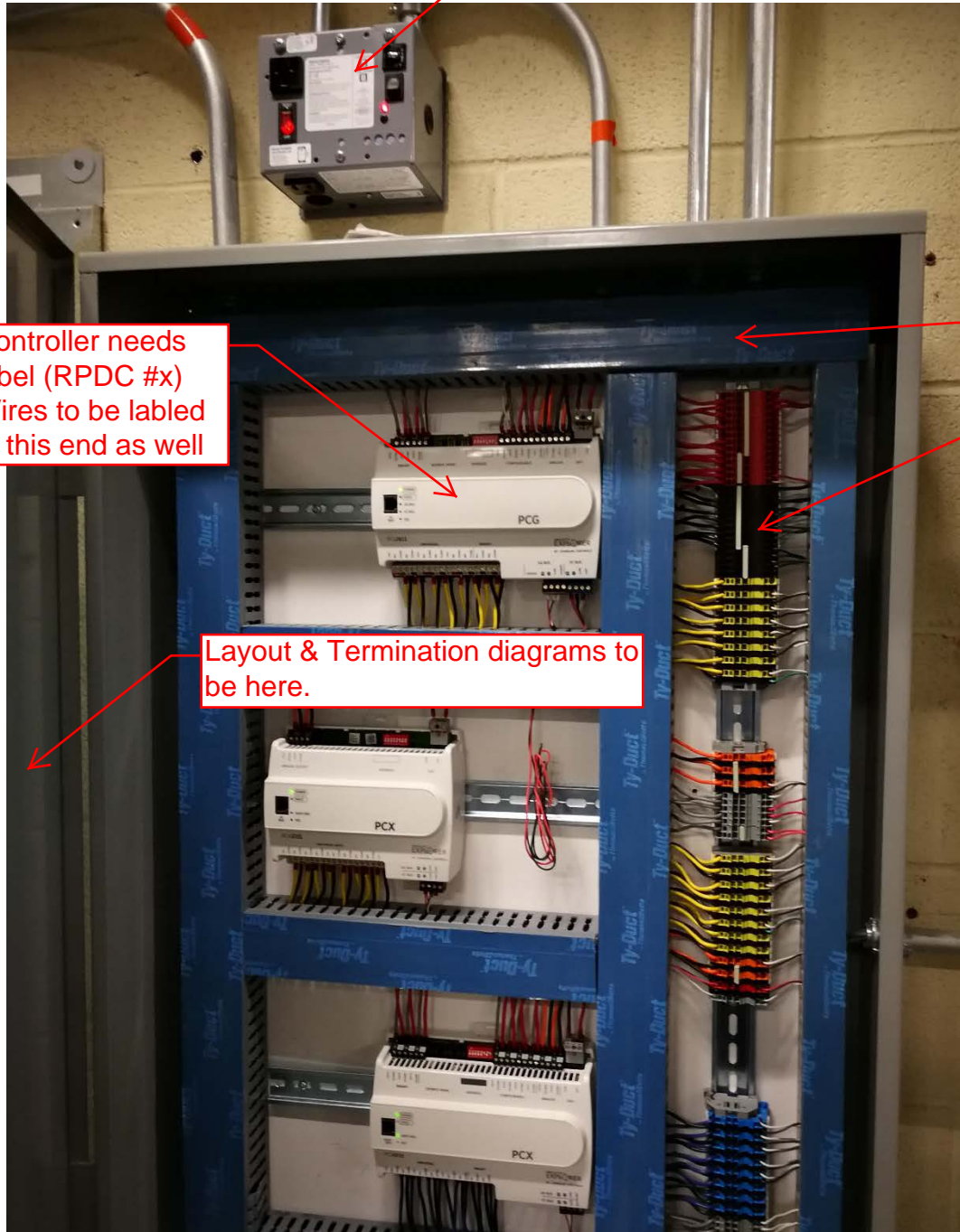
External Power Supply with isolation switch. Power Source must be identified on the power supply and in Power Plan shown in submittals and as-builts

Controller needs label (RPDC #x)
Wires to be labeled at this end as well

Layout & Termination diagrams to be here.

Cable Trays

Terminal Block on DIN Rail. Note Wires to be labeled on both ends with proper point name (BLR1ENA_CMD, etc). Acceptable to have tag behind cable trays to ensure a neat fit.



direct wiring to allowed, must terminal block

Need

No 120V supply M with isolat enclosure

this is isolation should outside control

panel layout & termination to go here

12V co in ra th

120V relays/
contactors must be
in separate NEMA
rated enclosure like
this

Appendix A4

CITY OF MISSISSAUGA

BAS SYSTEM ARCHITECTURES & COMMUNICATION PROTOCOLS

System Architectures

The new CoM BAS system architecture will be based on BacNet over IP controller technology using the project specified Network Cable (ie CAT 5/CAT6/CAT6E – Minimum CAT 5). The installing BAS contractor shall supply and install all necessary components of the BAS system including the Supervisory Controller(s) (SRPDC – JACE800) and any necessary switches/routers. The new facility BAS shall communicate to the Niagara N4 Supervisor using Fox Communication Protocol and shall communicate to all downstream field controllers using BacNet over IP. The CoM will provide a singular CoM IT network drop, all controller addressing shall be by the installing BAS contractor.

In some instances (where directed by CoM) connection to existing (non-obsolete) Legacy BAS systems already operating on either BacNet or LON network may be required. In those instances it may be applicable to retain existing 3-wire BacNet MS/TP or LON Networks. Approval from CoM is required in advance.

Connection to other OEMASC shall be via dedicated sub-networks using available open communication protocol of that systems (BacNet/IP, BacNET MSTP, LON, etc)

Description of system architecture is as follows:

- CoM IT Network to SRDPC (JACE 8000 Series Controller): 1-IP Drop using Specified Network Cable (ie CAT 5/CAT6/CAT6E)
- IT Network to dedicated managed switch/router: 1 IP Drop per managed switch using Specified Network Cable
- Dedicated BAS Managed Switch/Router to connect up-to four (4) BacNet-IP Subnetworks (per managed switch). Sub-networks can each handle up-to 20 IP Based field controllers (RPDC), daisy chained together in series using Specified Network Cable (ie CAT 5/CAT6/CAT6E)
- From RPDC to any Non-IP based Terminal Equipment controllers (TEC), install a new 3-wire MS/TP network from an RPDC connect multiple TEC in that same area of facility. (This only applies where BacNet IP terminal controllers are not available in the pre-approved Family of controllers – ie VAV Box controllers). **Contractors must identify this in their Bid Submission.**

- SRPDC (JACE) to be configured to manage the Sub-Network controller(s) using FOX Communication protocol. This limits the Niagara device count (for licensing) to one (1) per building.
- From the Sub-Network Controller(s) to RPDC the communication protocol shall be BacNet/IP.
- From RPDC to terminal equipment controllers (TEC) communication shall be BacNet IP or in certain instances BacNet MS/TP (see above).
- Connection to other OEMASC shall be a dedicated sub-network or via IP connection from OEMASC to CoM IT using available open communication protocol of that systems (BacNet/IP, BacNET MS/TP, LON, etc)

Refer to Drawing SK-2 Attached

Insert SK-2

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City of Mississauga Graphical Standard

- Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall show animation by shifting imaged based on the status of the object. The Graphical representation of dynamic equipment shall also be color coded based on equipment Status as follows:
 - Commanded ON and Status ON – Equipment shall be GREEN
 - Commanded ON and Status OFF – Equipment shall be FLASHING RED
 - Commanded OFF and Status OFF – No Color
 - Commanded OFF and Status ON – Equipment shall be FLASHING RED
- System graphics shall permit operators with authorized access level to command outputs and change operator settings directly from interactive command and value fields. Any object contained within the system graphics can be selected and opened to access the full set of object properties.
- System graphics can be custom created and modified while on-line with a built-in system graphics editor.
- All graphics shall be fully scalable
- The graphical user interface (GUI)shall employ browser-like functionality for ease of navigation. It shall include outside of the graphical viewing a navigation tree for quick viewing of the controllers associated with the building that is being accessed and access to, hierarchical structure of the database.
- Schedule times will be adjusted using graphical slider, without requiring any keyboard entry from the operator. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-menu. No entry of text shall be required. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.
- Development of the initial NIAGARA 4 CoM graphical template workstation shall occur during a pilot project with the successful vendor, City of Mississauga (CoM), and Consultant. The CoM and consultant shall meet with successful bidder to review examples of other projects and to discuss the new Niagara 4 CoM graphical standardization. The EMCS vendor will then create an initial pass at the graphics for the

pilot site for review. CoM and consultant to mark-up and send back with required changes. The approval of final version will be a reiterative process and the EMCS Vendor shall anticipate this to take multiple submissions before finalization. Some additional changes may also be required during the commissioning and will be carried out as part of the project.

- Access to the Template workstation will be provided to all vendors after in the initial pilot project and will be the basis of development for Customized Site Specific Graphics for all other CoM sites and EMCS projects.
- Using **Active Directory** each CoM user Access Login Name and Password will be assigned to a Group which will be used by the EMCS to determine the level of Authority when Accessing the System (refer to Master Specifications). Upon initial Log in to the EMCS Software, All Buildings/EMCS Installations connected to the CoM Intranet shall be presented in a Table Format or on a Mapping system (TBD - developed during the Pilot project) for selection by the User to Navigate to the desired system Installation. As systems are added to the CoM portfolio, the EMCS Vendor working on the specific project will be responsible for adding their site to the system.
- Once a site has been selected, the User Shall then be allowed to Navigate the Building EMCS Starting at the MAIN LANDING PAGE. A General description of Site Navigation as follows:
 - **Graphic Title:** Provide a prominent, descriptive title on each graphic page.
 - **Main Landing Page:** Once access has been granted to the operator and user level has been determined, the graphics shall display a picture of the building exterior (or possibly the 1st floor plan – TBD during pilot). Each page including the Main landing page shall have the same background file and color scheme with the City of Mississauga Corporate “LOGO” shown at all times on the Top Left.
 - **Common Elements:**
 - On the top right part of the Graphic Display shall be indication of the Critical Building Information including: **OAT Temp, heating system supply water Temp, cooling system supply water Temp. NOTE: Critical Information will be dependent on the Actual Building HVAC systems – i.e. Condenser/Ground Loop Temps, etc.**
 - Along the left side of the graphics shall be the System Menu Navigation Bars listing all floor plans and HVAC systems pages associated with the Building and colour-coded.

Note: All of the above elements shall be common to every graphical page.
Refer to Samples shown in these appendices.

- **Building Floor Plans:** A floor plan graphic for each of the building's floors (and roof) with dynamic display shall be provided and will be accessible through the Navigation Bar Menu along the bottom of all graphics. When possible, use the project's electronic drawing files (CAD files) for the graphic backgrounds. Clear names for important areas, such as "Main Conference Room" including room names and room numbers shall be provided. Include building features such as Elevators, Main Entrances, Stairs, etc. Include the location of mechanical rooms, major equipment, and control component locations, with corresponding links to the equipment graphics directly and in addition to the Navigation BAR menu along the left side of all graphics.
 - The floor plans graphic (Minimum 1 per floor) shall show dynamic display of space temperatures, DDC controllers' locations and identify which system or how many systems are serving this floor. Each system shall continue with the associated system color scheme and there shall be a graphical interface button provided for each system i.e. (HVAC units, Rooftop units, unit ventilators, etc.).
 - When the interface button for the corresponding system is activated, the graphic shall provide a navigational link to open up a new graphical window with the system details displayed. This link shall be in addition to the Navigation Bar Menu for Systems along the left hand side of all graphics.
 - Where thermostats are shown on the floor plan graphic, the operator shall be able to link to associated systems such as a fan coil unit, VAV terminal, radiation, unit ventilators or air handling units, etc. and display the System Graphic. This link shall also be in addition to the Navigation Bar Menu for Systems along the left hand side of all graphics.
- **Sub-floor plan Areas:** Where a building's floor plan is too large to adequately display on the screen, sub-divide the plan into distinct areas, and provide a separate graphic display for each area. The same level of detail requested in the building floor plan section above shall be provided.

- **System Graphics:** Provide a graphic page for each system controlled, accessible through the System Navigation Bar Menu along the bottom of all graphics and other links as described previously.
 - The system graphic shall be a dynamic representation of the actual system being controlled and shall display all control variables and command points including but not limited to Fan/Pump start/stop/status, Damper and Actuator Command, damper positions, stages of cooling and heating, etc. (Refer to sample graphics shown in these appendices)
 - Along the left side of the system graphic display the associated reset schedules (i.e. heating or cooling) with all set-points and parameters including the Calculated Set-Point shall be displayed, so the operator is able to edit set-points and parameters directly from the screen.
 - On the right side of the system display shall be a table with links to the system's associated time schedule (i.e. MBOS) and individual schedules such as Event Schedules (ES) and Timed Override Schedules (TOS). These Links will allow various users to view the schedules and users with sufficient access to edit and modify schedules and events as required.
 - System graphics shall be dynamic and color coded as described at the beginning of this Standard to show the operational status of the equipment.
 - Through the system display, the operator shall be able to interface with the system and provide commands to control the operation of the system and related devices including temporary and permanent over-rides (depending on user authority level).
 - On the bottom of every system display there shall be navigational buttons to link and display the written sequence of operations and the as-built wiring diagrams.
- **Settings Page:**
 - Each system page will have a link to associated Settings page.
 - The Settings page will only be accessible to specified user access levels and will access to view and modify schedules, adjustment of reset schedule parameters (ie – Outdoor Air Reset Schedules, etc), adjustment of temperature differential, time delays, and other control parameters as well as adjustment of all Alarm parameters.

- **Terminal Equipment Controller Quick Reference Summary Charts**
 - Where thermostats or equipment are shown on the floor plan graphic, the operator shall be able to link from this point to the associated systems such as Heat Pumps, VAV terminal, fan coils radiation elements, unit ventilators, exhaust fans or air handling units, etc. and display the individual Terminal Equipment system graphic. There shall also be a link provided through the Navigation Bar Menu along the left hand side of all graphics for Terminal Equipment Controller Quick Reference Summary graphics.
 - In addition to the individual equipment system displays there will be quick reference tables of summarizing all terminal equipment serving the floor or floor area i.e. (all VAV terminals, Heat Pumps, radiation elements, fan coils, etc.). These tables shall offer a quick view of the state of all units, on each particular floor area providing information on the status of units operation, temperatures, set-points, and commands modes, i.e. occupied/unoccupied, overrides and dampers, valves control statuses.
 - The operator with proper access level shall be able to utilize these tables to control and command set-point changes and trouble shoot the systems.
- **Dynamic update:** When the workstation is on line, all graphic I/O object values shall update with change- of- value services, or by operator selected discrete intervals.
- **Graphic Linking:** Provide forward and backward linking between floor plans, sub plans, and equipment.
- **Graphic Editing:** Provide all necessary software to create, modify, and delete the DDC graphics. Include the ability to store graphic symbols in a symbol directory stored on the Owner's server and the ability to import these symbols into the graphics. The system graphics editor also shall include a complete library of standard HVAC equipment graphics such as Chillers, Boilers, Air Handlers, Terminals, Fan coils, and Unit Ventilators. The library also shall include standard symbols for other equipment including Fans, Pumps, Coils, Valves, Piping, Dampers, and Ductwork.

Graphical Samples

Sample Graphics to be used as a guideline only for the various vendor Site specific Graphical Applications. As each vendor creates a new installation, screen shots of actual and approved graphics shall be inserted to update and/or replace the samples in the Master Specifications and form the new Template for future projects.

Initial graphical sample will be generated during the pilot project

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City of Mississauga - Typical Points List & Standard Sequences of Operation

Overview

This document forms a part of the City of Mississauga BAS Installation Standard. The document is intended to be a Design Guideline for the specifying Engineer/Consultant working on City of Mississauga (control system upgrade) projects and shall be used as the basis of all BAS design work for the City of Mississauga (CoM).

Engineers/Consultants working for the CoM shall use these points list and sequences as the starting point to design, modifying them to the extent necessary to meet the needs of a particular project. The final specifications issued by any Engineer/Consultant and used in the design and specification of building automation controls shall not deviate from the basic concepts and requirements set forth in this document.

Engineers/Consultants working for the CoM are expected to produce their own project specifications incorporating the elements and design principals of this Design Guideline and the CoM Master Specifications and shall make clear reference to these **City of Mississauga Master Specifications for EMCS Installation (Latest Revision)** within their own design document.

In order to create a facilities network of buildings that can be maintained and operated efficiently, each new BAS system designed and installed for the City of Mississauga (CoM) must conform to CoM BAS standard. The following outlines a **Typical Points list** and **standard sequence of operation** for a variety of systems found within the City of Mississauga Facilities. For new systems not currently included in the list, the specifying Engineer/Consultant shall use the same format, point naming conventions, and design principals to create additional templates for the guideline. The points list and sequences are to be submitted to the CoM project manager for review and approval by the City before incorporation into the BAS Design Guideline and the project specific specifications (the Engineer/Consultant should anticipate a reiterative process of submission/review/approval).

Application of Specified Sequences

- .1 The following sequences are generic in nature and are meant to form the basis of design for all CoM EMCS Projects
- .2 The sequences shall be used as the initial starting point for each project, customized by the specifying Consultant and tailored for the specifics of individual project and system requirements.
- .3 All project specific sequences to be submitted to the COM for review and approval prior to Tender.

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City of Mississauga - Typical Points List & Standard Sequences of Operation

Part 1 HVAC Operating Schedules & Modes (Common)

1.1 GENERAL:

- .1 Equipment/Systems will be controlled to operate continuously in a variety of different modes of operation. Control shall be done locally at RPDC, TEC and OEMASC, interfaced with the EMCS ESS through the SRPDC.
- .2 All scheduling shall be time of day (TOD) calendar based and shall factor in; Holidays, Weekends, and other modes of operation where indicated. In some cases, indoor or outdoor temperatures shall dictate a part of the permissible operation of equipment.
- .3 Whenever fan systems are scheduled “off”, outdoor and exhaust air dampers will be closed, hot water heating coil valves will be open, chilled water coil valves will be closed (except as noted), electrical heating coils, humidifiers, and refrigeration coils (DX cooling) shall be locked out. (as applicable)
- .4 Mixing damper and valve actuators shall be powered such that when the fan system is OFF (in either “auto” or “manual”) the actuators shall be de-energized and will return to the fail-safe position.

1.2 MASTER BUILDING OCCUPANCY SCHEDULE (MBOS):

- .1 The EMCS shall run each defined system (or groups of equipment/Systems) according to a Master System Occupancy Schedule (MSOSx), and then again individually for programmed events and temporary overrides outside of the MSOSx.
- .2 Occupied Mode
 - .1 The EMCS shall run the associated equipment/systems continuously according to the (MSOSx) occupied operating schedule. During occupied operation of the equipment, systems shall run according to a specified Time of Day (TOD) and calendar operating schedule. The specific **Mode of Operation** (Occupied/Unoccupied/Holiday/etc.) shall be identified as “MODE” and displayed on the systems page. The calendar and start/stop times shall be accessed through the associated system “Settings” page and adjustable through the graphics by assigned user levels.
 - .2 Each occupancy schedule shall have three distinct modes of operation – OCCUPIED, UNOCCUPIED, and HOLIDAY. **The Calendar dates for the Holidays shall be pulled from the EMCS ESS by the local EMCS SRPDC.**
 - .3 Activity Settings (AS)
 - .1 Various **Activity Settings** will be required for systems serving different rooms/spaces associated with the City of Mississauga Room Booking Database System (**NAME of System TBD**). The AS will permit different control settings based on the scheduled activity of the room/space that occur during the MSOSx (ie – minimum ventilation, pre-cool/heat time, room temperature, room humidity, ice surface temperature, lighting levels, etc) .
 - .2 The scheduled time of different AS shall occur through a specified methodology still to be defined by the City of Mississauga (example – programmed link to external database, or ACTIVITY SCHEDULE button on graphics, etc.). EMCS vendors shall be provided pre-programmed sub-routines for use and customization to accomplish the site/system specific sequence of operation associated with the Activity (example – Concert Settings, Orchestra Settings, Public Swim Settings,

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City of Mississauga - Typical Points List & Standard Sequences of Operation

Competitive Swim Settings, Yoga Settings, Aerobics Settings, etc) causing the system to take priority over all other specified modes of operation.

- .3 The EMCS shall operate all necessary HVAC system(s) associated with maintain the environmental settings of the Activity including all related axillary services as necessary (such as chillers, pumps, make-up air, exhaust, etc.) to allow for the specified conditioning of the specified activity with the Room/Zone. **Refer to ACTIVITY SETTINGS Table and individual Specified Sequence of Operation of associated systems.** The EMCS will utilize the Activity Settings for that room/zone when the booking starts and will return to default settings (NONE) when the booking is over.
- .4 When an Activity begins, the EMCS will provide graphical indication (on the system page) identifying the current “Activity”
- .5 Schedule of Modes and Settings
 - .1 **Designer/Consultant** (in collaboration with CoM project team) to complete a Facility Schedule (per site) of the systems, areas served operating schedules and activity settings to be included in specifications of new/replacement EMCS.
 - .2 Please see Sample Facility Schedule below:

Facility/Site Name

Master System Occupancy (MSOS) Schedules and Activity Settings

Sched #	System	Room(s)	MSOSx	Activity	Activity Settings	Notes
1	AHU 1	Gym A	6am to 11pm Mon to Fri	UNOCC (Default)	RMT_SP = UNOCC MIN OA = 0% LTG_CMD = OFF	AHU 1 will operate to the default “UNOCC” settings 10 Min (Adjustable) after the last booked activity setting.
			7am to 3 pm Sat/Sun Holidays - UNOCC	SPORT1 (Light Play)	RMT_SP = 22.5C MIN OA = 20% LTG_CMD = ON	Pre-Cool = 0min
				SPORT2 (Team Sports)	RMT_SP = 21.0C MIN OA = 25% LTG_CMD = ON	Pre-Cool = 5min
				VOTE (Election)	RMT_SP = 22.5C MIN OA = 35% LTG_CMD = ON	Pre-Cool = 15min
3	RTU 1	RM 201	6am to 7pm Mon to Fri	NONE (Default)	RMT_SP = UNOCC MIN OA = 0%	

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		(Multi-Purpose Rm)	7am to 3 pm Sat/Sun	MTG1 (<10 people)	RMT_SP = 22.5C MINOA = CO2_SP	Pre-cool = 0min CO2_SP = 900ppm
			Holidays - UNOCC	MTG2 (>10 people)	RMT_SP = 21.0C MIN OA = CO2_SP	Pre-cool = 5 min CO2_SP = 1000ppm
				CLASS1 (Art, Seniors)	RMT_SP = 23.0C MIN OA = CO2_SP	Pre-cool = 0 min CO2_SP= 900 ppm
				CLASS2 (Spin, Areobics)	RMT_SP = 20.5C MIN OA = CO2_SP	Pre-cool time = 7 min CO2_SP = 800ppm
3,4,...	System ID	Rooms served from booking systems	Primary operating schedule	Activities options in Room Booking Settings	Settings for the activity (adjustable on system settings page)	Additional control notes.

.3 Holiday Mode

- .1 During scheduled holidays, systems shall remain in their Unoccupied operational state.

.4 Unoccupied Mode

- .1 In un-occupied mode fans, heating, and cooling will all be de-energized, and the outside air dampers will be closed unless required by the specified sequence for maintaining un-occupied heating and cooling set points or as required for night purge/morning warm-up, etc.
- .2 For units with VSD's when cycled on the fans shall operate at a reduced speed of 60% output (user adjustable) to start, after 15 Min (adjustable) if the un-occupied heating/cooling setpoint has not be attained, the fan system will start to ramp up slowly until the unoccupied setpoints have been satisfied.

.5 Night Purge Mode

- .1 Between the hours of 3am and 5am, if the outdoor air temperature is between 10°C and 19°C (user adjustable via associated Settings page) and the average room temperature associated with a fan or make-up air system is above 26°C (user adjustable via associated settings page), the fan (or make-up air) system will be energized with economizer cooling until the space temperatures is 21°C (user adjustable via associated systems Settings page) and then shall be switched off.

.6 Morning Start-up Mode

- .1 The EMCS shall use an optimized morning start-up routine, incorporating outside air temperature, zone temperatures, heating valves and cooling valves positions, and past history of the building response to determine the optimum time to start the HVAC systems. The maximum start-up period shall not exceed 3 hours (adjustable).

.7 Activity Modes

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.1 The following Activity Modes shall be applied to each of the different Facility Types:

Typical Facility Activity Modes

Building Type	Activity Modes	Activity Settings	Notes
Indoor/Outdoor Ice Rinks	Unoccupied		
	Occupied		
	General Skating		
	Figure Skating		
	Ice Hockey		
	Tournament		
	Ice Skating		
Sports Complex	Unoccupied		
	Occupied		
	Sport 1		
	Sport 2		
	Sport 3		
	Sport 4		
Community Centres/Indoor Pools/Senior Citizen Centres	Unoccupied		
	Occupied		
	Swimming 1		
	Swimming 2		
	Sport 1		
	Sport 2		
	Sport 3		
	Sport 4		
	Party 1		
	Party 2		
	Party 3		
	Meeting 1		
	Meeting 2		
Admin Buildings, Transit, Depots/Yards, Libraries	Unoccupied		
	Occupied		
	Meeting 1		
	Meeting 2		
Cultural and Performing Arts, Golf Courses, Outdoor Pools	Unoccupied		
	Occupied		
	Event 1		
	Event 2		
	Event 3		

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1.3 TEMPORARY OVERRIDE SCHEDULES (TOS)

- .1 Temporary overrides will be provided to the operator through the thermostat override button or where the space sensor is flat plate (no occupancy button) through a graphical Override Button on the associated floor plan and HVAC system graphic. The override will enable the associated HVAC unit with fan operation and heating control only to maintain the Daytime Occupied Heating set point for a period of up to 2 hours (adjustable via associated Settings Page). Minimum ventilation setting shall remain 0% and no mechanical cooling shall be permitted.

1.4 ALARM MANAGEMENT

- .1 There shall be **Four (4)** types of primary alarms, Critical, Environmental, Maintenance, and Energy. The vendor shall set up EMCS system to provide appropriate level of response as follows:
 - .1 Critical Alarms:
 - .1 Critical Alarms are those designated to send a signal to the Security System and the following email address (BASAlerts@mississauga.ca) on site. There are no situations where a Critical Alarm only shows up on the graphics/alarming console, without sending a signal to the Security System and specified email. Refer to part 1.4.1.3 (to follow) for a detailed list of the CoM typical critical alarms.
 - .2 Critical alarms shall also provide indication on the graphics (Flashing Red) both the Enterprise Server Software (ESS) operator workstation(s) and workstations connected through the SRPDC.
 - .3 Records of a Critical Alarms shall be stored on the EMCS ESS and an Email generated and sent to the Owner's designate email address (BASAlerts@mississauga.ca) indicating the Building ID, Alarm Indication/Descriptor, Alarm Parameter, Time of Alarm, etc.
 - .2 Environmental Alarms:
 - .1 Environmental alarms shall provide indication on the graphics (Flashing Yellow) both the ESS operator workstation(s) and workstations connected through the SRPDC and shall remain in alarm until the condition has been corrected.
 - .2 The history or environmental alarms will not be recorded at the EMCS server.
 - .3 Maintenance Alarms:
 - .1 Maintenance alarms shall provide indication on the graphics (Solid Yellow) both the ESS operator workstation(s) and workstations connected through the SRPDC and shall remain in alarm until the specified alarm condition has been removed. For "Time Based" Maintenance Alarms, the graphical indication of alarm shall remain active for 2 hours then shall return to normal until the alarm conditions have been flagged again.
 - .2 A secondary separate graphic on the EMCS ESS shall be created by the EMCS Vendor and populated with live data to track the cumulative number of Maintenance Alarms at each site until reset by the Administrative User.
 - .3 Record of a Maintenance Alarm shall be stored on the EMCS Server, separated by site. NOTE: You could route maintenance alarms to an email as well or just have a dedicated graphical page on the EMCS server where Operator Level 1 & 2 go to daily/weekly and will see the alarms by site listed and then can be addressed at a later date.

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- .4 Energy Alarms:
 - .1 Energy alarms shall not generate any indication on the SRPDC graphics
 - .2 An EMCS ESS Graphical Page shall be created and populated with live data by the EMCS Vendor for Energy Alarms. The Graphic will have a listing of all sites with a cumulative running total of Energy alarms generated for each site. The number will continue to increase until reset by the Administrative Level User.
 - .3 A Record of an Energy Alarm shall be stored in the database at the EMCS ESS server. They shall also send out an Email to owner designated email indicating record of a new alarm.
 - .4 All alarm limits shall be as specified in the sequence of operation and with final set-up established during the commissioning process.
- .2 Alarms shall be set-up to be functional during the appropriate seasons and inactive when outside of the related season (i.e. – low heating water temperature alarms shall not be active during summer; chilled water alarms shall not be active after the central chilled water has been shut off to the building).
- .3 Alarms that are stored at the EMCS Server shall be stored under various file headings (i.e. Critical, Maintenance, Energy) date and time stamped to include when the occurred and the date of acknowledgement of the alarm parameter.
- .4 All alarms in database shall remain until cleared by the system administrator access level.

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Part 2 System Sequences

2.1 CRITICAL ALARMS

- .1 Critical alarms are designate specifically as alarms that send a direct signal to the Security Panel on site and to the following **email address: BASAlerts@mississauga.ca**. Each alarm type will have a separate digital output to the security panel. *Needs to be coordinated with Security company and process put in place for when they receive alarms – ie CALL OUT LIST.*
- .2 In addition to the output command to the security panel, critical alarms shall follow the requirements of part **1.4. Alarm Management**
- .3 Critical Alarm points will be listed in the points matrix for each site and may include the following:
 - Low Boiler Temp (HWST<35°C when OAT<5°C)
 - Low Room Temp (RMT<14°C when OAT<5°C)
 - Cooling Tower Temp (Tower Leaving Temp>40°C or <15°C)
 - Temperature based alarms above shall all have an adjustable time delay before triggering alarm (10 min – adjustable)
 - Heat Pump Flow (No Flow indication or pump status for >30s)
 - Power Phase Loss (Monitored Dry Contact)
 - Sewage pump level (Monitored High Limit Sensor)
 - Sump pump level (Monitored High Limit Sensor)
 - Greenhouse temp (Dry Contact or Specified EMCS Temp Sensor Limit)
 - Inverter Trouble (Monitored Dry Contact)
 - Generator Trouble (Monitored Dry Contact)
 - Server high temp (Server RMT>26°C or monitored dry contact)
 - *LIST ANY COM SPECIFIC CRITICAL ALARMS HERE, DELTE THOSE NOT DESIGNATED AS CRITICAL*
- .4 All alarm settings shall be user adjustable via the Associated Settings page by the assigned level of access.
- .5 Adjustable Points (to be displayed and accessed on system Setting Page):
 - .1 Alarm Settings – (setpoints and time delay parameters as noted in part 2.1.3 Alarms)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

NOTE: These are the typical systems we have sequences for please review with your Operations Group to see Typical Points/Sequence/alarms – the list can be added to at a later date as projects are put out for tender and then added to future revisions of the Master Spec

2.2 SINGLE ZONE AHU SYSTEMS

.1 Anticipated Points:

- AHU_xSF_STS -Supply Fan Status (1 DI)
- AHU_xSF_CMD -Supply Fan Start/Stop (1 DO)
- AHU_xRF_STS -Return Fan Status (1 DI)
- AHU_xRF_CMD -Return Fan Start/Stop (1 DO)
- AHU_xMAT_T -Mixed Air Temp (AI)
- AHU_xMADPR_MOD -Mixed Air Dampers MOD (1 AO)
- AHU_xSAT_T -Supply Air Temp (1 AI)
- AHU_xRAT_T -Return Air Temp (1 AI)
- AHU_xHTGVLV_MOD -Heating Coil Valve MOD (1 AO)
- AHU_xHTGPMP_CMD -Heating Coil Pump CMD (1 DO)
- AHU_xHTGPMP_STS -Heating Coil Pump Status (1 DI)
- AHU_xCLGVLV_MOD -Cooling Coil Valve MOD (1 AO)

or

- AHU_xCLG_x_CMD -Cooling Coil DX Stage x (1 DO)
- AHU_xFRZ_ALM - Freeze Stat Status – (1 DI)

Note: All Freeze Stats should be DPDT, hardwired to shut down motor starters (or VFD as applicable) and disable power to damper and valve actuators. The second set of contacts shall be monitored by DDC Controller.

.2 Optional Points (by project):

- **CO2 Control**
 - AHU_xRACO2_PPM -Return Air CO2 Level (1 AI)
- **VSD Control**
 - AHU_xSFVSD_CMD -Supply Fan VSD Start/Stop (1 DO)
 - AHU_xSFVSD_MOD -Supply Fan VSD Freq Modulation (1AO)
 - AHU_xSFVSD_FBK -Supply Fan VSD Freq Feedback (1 AI)
 - AHU_xSFVSD_ALM -Supply Fan VSD Fault Alm Status (1 DI)
 - AHU_xRFVSD_CMD -Return Fan VSD Start/Stop (1 DO)
 - AHU_xRFVSD_MOD -Return Fan VSD Modulation (1 AO)
 - AHU_xRFVSD_FBK -Return Fan VSD Freq Feedback (1 AI)
 - AHU_xRFVSD_ALM -Return Fan VSD Fault Alarm (1 DI)

.3 Start/Stop:

- .1 The EMCS shall enable the fan system to start when commanded on through either MSOS_x or other specified modes of operation. When commanded on, supply fan shall start first. Once the supply fan status is proven on, the EMCS shall start the return fan. Once return fan status is proven the EMCS shall allow application of the specified mixed air, heating and cooling sequences. (Note: Where fans are hard wire interlocked – both shall be started simultaneously).

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City of Mississauga - Typical Points List & Standard Sequences of Operation

- .2 When the EMCS sends the signal to stop; both fans shall stop, mixed air dampers shall close to full re-circulation, heating and cooling valves shall return to their fail-safe position.
- .3 When the system is in UNOCCUPIED mode (outside of the MSOSx) the system shall remain off unless called back on in another mode of operation (Night Purge, Optimum Start, Night Set Back).
- .4 When the system is activated in Night Setback Mode (NSB) the fan system shall come on in full recirculation to maintain the specified unoccupied heating/cooling set points.
- .4 Mixed Air/Supply Air Control
 - .1 During occupied operation of the unit the EMCS shall modulate the mixed air dampers (MADPR) between minimum ventilation and 100% outside air, in sequence with heating and cooling coils to maintain the supply air set-point (SAT_SPT). The EMCS shall reset the supply air temperature to maintain the space temperature set point as follows:

.2	Space Temp SP Deviation	Supply Air Temp Set-point
	RMT_SP -2 °C	26 °C
	RMT_SP +2oC	14°C
 - .3 The minimum ventilation set point and damper position shall be displayed on the system graphics. Initial Minimum Ventilation set point shall be 25% (Adjustable) or as outlined in the **Master Facility Operating and Settings Schedule** listed for the project.
 - .4 A mixed air low limit set-point (MAT-LL) shall be used to override the mixed air dampers to maintain a minimum temperature of 6.6 °C (adjustable and displayed on “System” graphics).
 - .5 If the MAT is below the MAT-LL the EMCS shall generate an **Environmental Alarm**.
 - .6 If the MAT-LL requires the dampers to be below the Minimum Ventilation setting for more than 2 minutes (adjustable) the EMCS shall generate a **Maintenance Alarm**.
 - .7 If the outdoor temperature rises above the economizer set point (ECON-SPT) of 18°C (adjustable and displayed on system graphics) and mechanical cooling is available, the mechanical cooling strategy shall be as follows:
 - Mixed air dampers shall revert to minimum ventilation position.
 - When the space (or return) temperature rises 1.0°C above the occupied cooling set-point, the cooling valve shall start to modulate (or DX cooling shall be energized) in order to satisfy the cooling requirements.
 - When the space temperature drops 1.0°C below the occupied cooling set point of 23°C (adjustable), the cooling valve shall modulate closed (or DX cooling shall be switched off).
- .5 Night Setback Control
 - .1 During un-occupied operating, the fan system shall remain off unless the space temperature falls below the Night Set-Back Temperature of 18°C (adjustable).
 - .2 When the space temperature falls to NSB_SPT -0.5°C, the fan system shall be enabled in full recirculation mode, heating valve full open, until the space temperature reaches NSB_SPT +1.0°C. The fan system will then shut off until the next cycle.

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- .6 (Optional) Minimum Ventilation and CO2 Control
 - .1 The maximum Minimum Ventilation Setting shall be 25% (adjustable via associated settings pages). The EMCS shall monitor return air CO2 levels and lower the active minimum ventilation from the (Maximum) minimum ventilation of 25% down to 0% based on maintain a maximum CO2 level of 900ppm.
 - .2 When the RA CO2 < 900 ppm, the EMCS shall reduce the active Minimum Ventilation setting by 2% every minute until reaching 0% or until the RACO2 > 900ppm.
 - .3 When the RACO2 > 900ppm the EMCS shall increase the active minimum damper position until reaching the (Maximum) minimum ventilation setting. If the MAT is below the MAT-LL, the EMCS shall generate an **Environmental Alarm**.
- .7 (Optional) Variable Speed Fan Control
 - .1 Application – for large spaces with light occupancy/variable occupancy ie Atrium
 - .2 The EMCS will modulate the supply fan variable speed drive (VSD) based on space conditions as described below. The return fan VSD shall track the supply fan VSD at an adjustable offset as established by the air balancer at the start of the project.
 - .3 The EMCS shall reset the supply air temperature to maintain the space temperature set point as defined in 1.4.2.4 (Single Zone AHU Mixed Air/Supply Air Control)
 - .4 Per the specified sequence, the EMCS shall modulate heating/cooling valves and mixing dampers in sequence to achieve SAT_SP. On initial start-up the supply fan shall operate at speed of 60% (user adjustable). When the space temperature is more than 1.5C outside of the heating/cooling set point dead band, the BAS shall increase the VSD's speed to a maximum of 100% (with ramp duration of 240 seconds or until the space temperature set point is satisfied). When the space temperature set point is satisfied for more than 5 minutes (adjustable), the fan shall start to reduce speed (over ramp duration of 240 seconds) until reaching the minimum speed setting or until the space temperatures starts to fall outside of occupied temperature dead band.
 - .5 Upon shutdown of the fan system, both the supply and return fan VSD's shall stop and the speed modulation signal shall go to 0%.
- .8 Heating Coil Circulation Pump Control (where applicable)
 - .1 If the outdoor temperature rises above the Warm Weather Lock Out Set Point (WWLO_SPT) (Refer to Heating Plant Sequences and Graphics) the heating coil pump shall turn off.
 - .2 If the outdoor air temperature is below 5°C (41°F) and the pump status is "off", the EMCS shall generate a maintenance alarm.
- .9 Safeties
 - .1 Low Temperature Protection Control: When air temperature downstream of the heating coil drops below 5°C (40°F - adjustable, as sensed by low limit (DPDT) freeze stat), the supply and return fans will shut down, outdoor air dampers will close and return air damper will open, the heating/cooling coil valves will open to full flow to the coil. A maintenance alarm will be generated. The freeze stat will need to be manually reset for normal operation to resume.
 - .2 High Temperature Protection Control: If high temperature limit located in the return air duct rises above the setting of 60°C the supply and return fans shall shut down and

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- a maintenance alarm will be generated. Once the high temperature protection control has been manually reset, the unit will return to normal control.
- .3 Fire Alarm Fan Shutdown: Where Fire Alarm interlocks exist, the EMCS shall not restrict the fire alarm system from shutting down all fans on a fire alarm condition (with starter in either hand or auto position). Where FA panel is monitored by EMCS upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.
- .10 Alarms
- .1 **Critical**
- .1 None
- .2 **Environmental**
- .1 Fan Status vs Command
- .2 CO2 Level Alarms (900ppm adjustable, if CO2 sensor present)
- .3 Supply, Mixed, Return Air, High and Low Limits (adjustable)
- .3 **Maintenance**
- .1 Freeze Stat Alarm
- .2 Heating Coil Pump Status Off Below 5°C (adjustable)
- .3 Mixed air dampers operating below the Minimum Ventilation setting for more than 2 minutes (adjustable)
- .4 When OAT < 0°C (adjustable) and mixed air dampers operating above the minimum setting for more than 2 minutes (adjustable)
- .4 **Energy Alarms**
- .1 Fan Status On for more than 2 hours cumulatively (adjustable) during un-occupied (NSB) operation.
- .2 Fan system operating in Occupied Mode outside of Originally Scheduled MSOSx
- .3 VFD Modulation greater than 80% (adjustable) for more than 2 hours cumulatively (adjustable) during occupied operation.
- .11 The initial set up values for all alarms shall be established during the commissioning process.
- .12 Adjustable Points (to be displayed and made adjustable via the system “Settings” Page)
- MSOS
 - Activity Settings (where applicable)
 - Minimum Ventilation Setpoint
 - Supply Air/Return/Space Air Reset Schedule Parameters
 - Mixed Air Temperature Low Limit (MATLL)
 - MATLL Time Delay
 - Economizer Setpoint (ECON_SPT)
 - Occupied Heating/Cooling Setpoints
 - Warm Weather Lockout Setpoint (Displayed, adjustable only from Heating Plant Graphics)
 - Alarm Settings – (setpoints and time delay parameters as noted in part 1.4.2.10 Alarms)

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2.3 MULTI-ROOM AHU SYSTEMS (RECIRCULATORY)

.1 Anticipated Points:

- | | |
|--|----------------------------------|
| • AHU _x SF_STS | -Supply Fan Status (1 DI) |
| • AHU _x SF_CMD | -Supply Fan Start/Stop (1 DO) |
| • AHU _x RF_STS | -Return Fan Status (1 DI) |
| • AHU _x RF_CMD | -Return Fan Start/Stop (1 DO) |
| • AHU _x MAT_T | -Mixed Air Temp (AI) |
| • AHU _x MADPR_MOD | -Mixed Air Dampers MOD (1 AO) |
| • AHU _x SAT_T | -Supply Air Temp (1 AI) |
| • AHU _x RAT_T | -Return Air Temp (1 AI) |
| • AHU _x HTGVLV_MOD | -Heating Coil Valve MOD (1 AO) |
| • | |
| • AHU _x HTGPMP_CMD | -Heating Coil Pump CMD (1 DO) |
| • AHU _x HTGPMP_STS | -Heating Coil Pump Status (1 DI) |
| • AHU _x CLGVLV_MOD | -Cooling Coil Valve MOD (1 AO) |
| | or |
| • AHU _x CLG _x _CMD | -Cooling Coil DX Stage x (1 DO) |
| • AHU _x FRZ_ALM | - Freeze Stat Status – (1 DI) |

Note: All Freeze Stats should be DPDT, hardwired to shut down motor starters (or VFD as applicable) and disable power to damper and valve actuators. The second set of contacts shall be monitored by DDC Controller.

.2 Start/Stop:

- .1 The EMCS shall enable the fan system to start when commanded on through either MSOS_x or other specified modes of operation. When commanded on, supply fan shall start first. Once the supply fan status is proven on, the EMCS shall start the return fan. Once return fan status is proven the EMCS shall allow application of the specified mixed air damper and heating sequences. (Note: Where fans are hard wire interlocked – both shall be started simultaneously).
- .2 When the EMCS sends the signal to stop; both fans shall stop, mixed air dampers shall close to full re-circulation, heating valves shall return to their fail-safe position.

.2 Mixed Air/Supply Air Control

- .1 During occupied operation of the unit the EMCS shall modulate the mixed air dampers (MADPR) between minimum ventilation setting and 100% outside air, in sequence with heating coil to maintain the supply air set-point (SAT_SPT). The EMCS shall reset the supply air temperature to maintain the space (or return air) temperature as follows:

Return Air/Space Temp	Supply Air Temp Set-point
RAT/RMT	SAT_SPT
20°C (adjustable)	22°C (adjustable)
24°C (adjustable)	18°C (adjustable)

- .2 The minimum ventilation set point and damper position shall be displayed on the system graphics. Initial Minimum Ventilation set point shall be 30% (Adjustable).

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- .3 A mixed air low limit set-point (MAT_LL) shall override the mixed air dampers to maintain a minimum temperature of 6.6°C (adjustable and displayed on system graphics).
- .4 If the MAT is below the MAT_LL, the EMCS shall generate an **Environmental Alarm**.
- .5 If the MAT_LL requires the dampers to be below the Minimum Ventilation setting for more than 2 minutes (adjustable) the EMCS shall generate a **Maintenance Alarm**.
- .3 Heating Coil Circulation Pump Control
 - .1 If the outdoor temperature rises above the Warm Weather Lock Out Set Point (WWLO_SPT) (Refer to Heating Plant Sequences and Graphics) the heating coil pump shall turn off.
 - .2 If the outdoor air temperature is below 5°C and the pump status is “off”, the EMCS shall generate a maintenance alarm.
- .4 Safeties
 - .1 Low Temperature Protection Control: When air temperature downstream of the heating coil drops below 5°C (adjustable - as sensed by low limit (DPDT) freeze stat), the supply and return fans will shut down, outdoor air dampers will close and return air damper will open, the heating/cooling coil valves will open to full flow to the coil. A maintenance alarm will be generated. The freeze stat will need to be manually reset for normal operation to resume.
 - .2 High Temperature Protection Control: If high temperature limit located in the return air duct rises above the setting of 60°C the supply and return fans shall shut down and a maintenance alarm will be generated. Once the high temperature protection control has been manually reset, the unit will return to normal control.
 - .3 Fire Alarm Fan Shutdown: Where Fire Alarm interlocks exist, the EMCS shall not restrict the fire alarm system from shutting down all fans on a fire alarm condition (with starter in either hand or auto position). Where FA panel is monitored by EMCS upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.
- .5 Alarms
 - .1 **Critical**
 - .1 None
 - .2 **Environmental**
 - .1 Fan Status vs Command
 - .2 Supply, Mixed, Return Air, High and Low Limits
 - .3 **Maintenance**
 - .1 Freeze Stat Alarm
 - .2 Heating Coil Pump Status Off Below 5°C (Adjustable) for more than 1 Min (adjustable)
 - .3 Mixed air dampers operating below the Minimum Ventilation setting for more than 2 minutes (adjustable)
 - .4 When OAT < 0°C (adjustable) and mixed air dampers operating above the minimum setting for more than 2 minutes (adjustable)
 - .4 **Energy Alarms**

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- .1 Fan system operating in Occupied Mode outside of Originally Scheduled MSOSx
- .2 Fan status “On” for more than 5 minutes outside of MSOSx.
- .5 The initial set up values for all alarms shall be established during the commissioning process.
- .6 Adjustable Points (to be displayed on system Setting Page)
 - MSOS
 - Minimum Ventilation Setpoint
 - Supply Air/Return Air Reset Schedule Parameters
 - Mixed Air Temperature Low Limit (MATLL)
 - MATLL Time Delay
 - Economizer Setpoint (ECON_SPT)
 - Occupied Cooling Setpoint
 - Warm Weather Lockout Setpoint (Displayed, adjustable from Heating Plant Graphics
 - Alarm Settings – (setpoints and time delay parameters as noted in part 2.3.5 Alarms)

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2.4 MAKE-UP AIR SYSTEMS (100% OA)

.1 Anticipated Points:

• MUASFS_STS	-Supply Fan Status (1 DI)
• MUASFS_CMD	-Supply Fan Start/Stop (1 DO)
• MUAXOADPR_CMD	-OA Damper Command (1DO)
• MUAXOADPR_STS	-OA Damper Proving Switch Status (1DI)
• MUASAT_T	-Supply Air Temp (1 AI)
• MUAXEAT_T	-Return Air Temperature (1AI)
• MUAXEAH_RH	-Exhaust Air Humidity (1AI)
• MUAXHTGVLV_MOD	-Heating Coil Valve MOD (1 AO)
• MUAXCLGVLV_MOD	-Cooling Coil Valve MOD (1 AO)
• MUAXHTGPMP_CMD	-Heating Coil Pump CMD (1 DO)
• MUAXHTGPMP_STS	-Heating Coil Pump Status (1 DI)
• MUAXFRZ_ALM	-Freeze Stat Status – (1 DI)
• EFX_STS	-Exhaust Fan Status (1DI)
• EFX_CMD	-Exhaust Fan Command (1DO)
• MAUXEAT_T	-Exhaust Air Temp (1AI)

.2 Start/Stop:

- .1 The EMCS shall enable the fan system(s) to start when commanded on through either MSOSx or other specified modes of operation.
- .2 When commanded on, the outdoor air damper shall open first. Once damper position is proven open, the supply fan shall be allowed to start. If after 30 seconds (after the start command) the fan status is “off” the outdoor air damper shall be closed.
- .3 When the EMCS sends the signal to stop; the fans shall stop, outdoor air damper shall close, and the heating valve shall return to the fail-safe (open) position.
- .4 The associated classroom exhaust fan (where applicable) shall operate with the supply fan.

.3 Supply Air Control

- .1 During occupied operation of the unit the EMCS shall modulate the heating coil to maintain the supply air set-point (SAT-SPT). The EMCS shall reset the supply air temperature to maintain the space (or return air) temperature as follows:

Return Air/Space Temp	Supply Air Temp Set-point
RAT/RMT	SAT_SPT
20°C (adjustable)	22°C (adjustable)
24°C (adjustable)	18°C (adjustable)

.4 Exhaust Air Humidity Control

- .1 During Occupied operation of the unit, when ever mechanical cooling is available, the EMCS shall modulate the cooling coil valve to maintain the exhaust air humidity level set point (EAH_SPT) of 50% (Adjustable).

.5 Heating Coil Circulation Pump Control

- .1 If the outdoor temperature rises above the Heating Lock Out Set Point (HLO_SPT) of 15oC (adjustable and displayed on heating plant graphics) the heating coil pump shall turn off.

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- .2 If the outdoor air temperature is below 5oC (41oF) and the pump status is “off”, the EMCS shall not allow the fan to operate and shall generate a **maintenance alarm**.
- .6 Safeties
 - .1 The outdoor air damper shall be wired in such a way that when the fan starter is in the “Hand” position the outdoor air damper shall drive open and the fan will start after the damper switch has proven the damper to be open. When Starter is in the “Off” position, the outdoor air damper shall be de-energized closed, and the fan shall remain off.
 - .2 Low Temperature Protection Control: When air temperature downstream of the heating coil drops below 5oC (adjustable, as sensed by low limit (DPDT) freeze stat), the supply fan will shut down, the outdoor air damper will be de-energized closed, and the heating valve will be de-energized open to allow full flow to the coil. A maintenance alarm will be generated. The freeze stat will need to be manually reset for normal operation to resume.
 - .3 Fire Alarm Fan Shutdown: Where Fire Alarm interlocks exist, the EMCS shall not restrict the fire alarm system from shutting down all fans on a fire alarm condition (with starter in either hand or auto position). Where FA panel is monitored by EMCS< upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.
- .7 Alarms
 - .1 **Critical**
 - .1 None
 - .2 **Environmental**
 - .1 Fan Status vs Command
 - .2 Supply Air High and Low Limits
 - .3 **Maintenance**
 - .1 Freeze Stat Alarm
 - .2 Heating Coil Pump Status Off Below 5oC (adjustable)
 - .3 Fan Command “On” but damper status not open after 40s (adjustable)
 - .4 **Energy Alarms**
 - .1 Fan system operating in Occupied Mode outside of Originally Scheduled MSOSx
 - .2 Fan status “On” for more than 5 minutes outside of MSOSx
 - .5 The initial set up values for all alarms shall be established during the commissioning process.
- .8 Adjustable Points (to be displayed on system Setting Page)
 - MSOSx Schedules
 - Initial Start-Up Heating Valve Ramp Time
 - SAT-LL and Time Delay
 - Supply Air Temperature Reset Schedule Parameters
 - Return Air Humidity Setpoint
 - Warm Weather Lockout Setpoint (Displayed, adjustable from Heating Plant Graphics
 - Cold Weather Cooling Lock Out Setpoint

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- Alarm Settings – (setpoints and time delay parameters as noted in part 2.4.7 Alarms)

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2.5 MAKE-UP SYSTEM (100% OA) WITH ENERGY RECOVERY

.1 Anticipated Points

• MUAXFAN_CMD	- Supply/Exhaust Fan Start/Stop (1 DO)
• MUAXSF_STS	- Supply Status (1 DI)
• MUAXEF_STS	- Exhaust Fan Status (1 DI)
• MUAXDPR_CMD	- OA/EA Damper Command (1 DO)
• MUAXOADPR_STS	- OA Damper Proving Switch Status (1 DI)
• MUAXEADPR_STS	- EA Damper Proving Switch Status (1 DI)
• MUAXOAT_T	- Outdoor Air Temperature (1 AI)
• MUAXERWLAT_T	- ERW Leaving Air Temperature (1AI)
• MUAXRAT_T	- Return Air Temperature (1AI)
• MUAXRAH_RH	- Return Air Humidity (1AI)
• MUAXEAT_T	- Exhaust Air Temperature (1AI)
• MUAXSAT_T	- Supply Air Temp (1 AI)
• MUAXERW_CMD	- Energy Recovery Wheel Command (1 DO)
• MUAXERW_STS	- Energy Recovery Wheel Status (1 DI)
• MUAXHTGVLV_MOD	- Heating Coil Valve Modulate (1 AO)
• MUAXHTGMPA_CMD	- MUA Htg Pump A Command (1DO)
• MUAXHTGMPA_STS	- MUA Htg Pump A Status (1DI)
• MUAXHTGMPB_CMD	- MUA Htg Pump B Command (1DO)
• MUAXHTGMPB_STS	- MUA Htg Pump B Status (1DI)
• MUAXFRZ_ALM	- Freeze Stat Status (1 DI)

Note: The Freeze Stat should be DPDT hardwired to shut down VSD's and disable power to actuators. The second set of contacts is to be monitored by DDC Controller.

• MUAXCLG1_CMD	- DX Cooling Stage 1 (1DO)
• MUAXCLG2_CMD	- DX Cooling Stage 2 (1DO)
Or	
• MUAXCLGVLV_MOD	- Cooling Coil Valve Modulate (1AO)

.2 Start/Stop:

- .1 The EMCS shall enable the fan system to start when commanded on through either MSOSx or other specified modes of operation.
- .2 When commanded on, the outdoor air damper and exhaust air dampers shall open first. Once damper positions are proven open, the supply and exhaust fans shall be allowed to start. If after 30 seconds (after the start command) either fan status is "off" the outdoor and exhaust air dampers shall be closed.
- .3 When the fans are off the heating valve shall be powered off and remain in the full open (Normal) position. Once the fans are enabled, the heating valve shall be powered and allowed to modulate under EMCS control. The EMCS shall slowly modulate the heating valve from 100% to 20% over 5 minutes (adjustable) or until reaching the SAT_LL. Once reaching 20% the heating valve shall be allowed to operate according to the intended control sequence.
- .4 When the EMCS sends the signal to stop; the fans shall stop, outdoor and exhaust air dampers shall close, and the heating valve shall return to the fail-safe (open) position.

.3 Supply Air Temperature Control:

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- .1 When the MUA fan status is “ON” the ERV, heating coil valve and stages of mechanical cooling shall be operated in sequence to maintain the supply air temperature set point.
- .2 During occupied operation, when the outdoor air temperature is below 15oC (adjustable) the ERV shall be allowed to operate and mechanical cooling shall remain off. When the OAT is less than 10oC or greater than 18oC (adjustable) the ERV shall remain energized.
- .3 The supply temperature sensor shall be used as a low limit control and shall override the heating valve if the supply air temperature falls below 8°C (adjustable). The supply air set-point shall be reset based on the following schedule (Heating and Cooling):

Outdoor Air Temperature OAT-T	Supply Air Temperature SAT-SPT
< 10°C (adjustable)	23°C (adjustable)
>18°C (adjustable)	15°C (adjustable)

- .4 Return Air Humidity Control
 - .1 Enable stages of mechanical cooling to maintain the maximum return air humidity setpoint of 55% (adjustable)
- .5 Cold Weather Cooling Lockout
 - .1 When OAT < 15°C (adjustable), mechanical cooling shall be locked out.
 - .2 Mechanical cooling shall also be locked out during summer operation unless required by Event programming.
- .6 Heating Coil Circulation Pump Control
 - .1 If the outdoor temperature rises above the Heating Lock Out Set Point (HLO_SPT) of 15oC (adjustable and displayed on heating plant graphics) the heating coil pump shall turn off.
 - .2 If the outdoor air temperature is below 5oC (41oF) and the pump status is “off”, the EMCS shall not allow the fan to operate and shall generate a maintenance alarm.
 - .3 If there is a secondary coil circulation pump (standby), if the lead (operational) pump status is lost, the standby pump shall become operational and a maintenance alarm shall be generated.
 - .4 If the lead pump status returns to “On” both pumps shall operate together for a period of 30s and then the standby pump shall be shut off.
- .7 Safeties
 - .1 The outdoor air damper and heating valve shall be powered in such a way that whether the fan starter is in the “Hand” or “Auto” position, the outdoor air damper shall drive open first and damper status must prove open before the fan will start. Once the fan has started the heating valve will be energized and put under control.
 - .2 When Starter is in the “Off” position or commanded off by the EMCS, the outdoor air damper and heating valve shall be de-energized closing the damper and opening the heating valve while the fan remains off.

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- .3 Low Temperature Protection Control: When air temperature downstream of the heating coil drops below 5°C (adjustable, as sensed by low limit (DPDT) freeze stat), the supply fan will shut down, the outdoor air damper will be de-energized closed, and the heating valve will be de-energized open to allow full flow to the coil. A maintenance alarm will be generated. The freeze stat will need to be manually reset for normal operation to resume.
- .4 Fire Alarm Fan Shutdown: Where Fire Alarm interlocks exist, the EMCS shall not restrict the fire alarm system from shutting down all fans on a fire alarm condition (with starter in either hand or auto position). Where FA panel is monitored by EMCS< upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.
- .8 Alarms
 - .1 **Critical**
 - .1 None
 - .2 **Environmental**
 - .1 Fan Status vs Command
 - .2 Supply Air High and Low Limits
 - .3 **Maintenance**
 - .1 Freeze Stat Alarm
 - .2 (Lead) Heating Coil Pump Status Off Below 5oC (Adjustable)
 - .3 Lead Pump status lost; standby pump becomes energized
 - .4 Fan Command “On” but damper status not open after 40s (adjustable)
 - .4 **Energy Alarms**
 - .1 Fan system operating in Occupied Mode outside of Originally Scheduled MSOSx
 - .2 Fan status “On” for more than 5 minutes outside of MSOSx
 - .3 Coil circulation pump status is ON when OAT> 10oC
 - .4 Mechanical Cooling ON outside of MSOSx or programmed event.
 - .5 The initial set up values for all alarms shall be established during the commissioning process.
- .9 Adjustable Points (to be displayed on system Setting Page)
 - MSOSx Schedules
 - Initial Start-Up Heating Valve Ramp Time
 - ERV cooling enable temperature
 - ERV heating enable temperature
 - SAT-LL
 - Supply Air Temperature Reset Schedule Parameters
 - Return Air Humidity Setpoint
 - Warm Weather Lockout Setpoint (Displayed, adjustable from Heating Plant Graphics
 - Cold Weather Cooling Lock Out Setpoint
 - Alarm Settings – (setpoints and time delay parameters as noted in part 2.5.8 Alarms)

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2.6 VARIABLE VOLUME AHU SYSTEMS

.1 Anticipated Points:

- | | |
|------------------------------|--|
| • AHU _x SFVSD_CMD | - Supply Fan VSD Start/Stop (1 DO) |
| • AHU _x SFVSD_MOD | - Supply Fan VSD freq Modulation (1AO) |
| • AHU _x SFVSD_FBK | - Supply Fan VSD freq feedback (1 AI) |
| • AHU _x SFVSD_ALM | - Supply Fan VSD Fault Alarm (1 DI) |
| • AHU _x RFVSD_CMD | - Return Fan VSD Start/Stop (1 DO) |
| • AHU _x RFVSD_MOD | - Return Fan VSD Freq Modulation (1AO) |
| • AHU _x RFVSD_FBK | - Return Fan VSD Frequency Feedback (1 AI) |
| • AHU _x RFVSD_ALM | - Return Fan VSD Fault Alarm (1 DI) |
| • AHU _x MAT_T | - Mixed Air Temp (AI) |
| • AHU _x MADPR-MOD | - Mixed Air Dampers Modulation (1 AO) |
| • AHU _x SAT_T | - Supply Air Temp (1 AI) |
| • AHU _x SADSP_PRS | - Supply Air Duct Static Pressure (AI) |
| • AHU _x SAHSP_ALM | - Supply Air High Static Pressure Limit (DI) |

Note: The Duct Pressure High Limit switch should be hardwired to shut down VSD's and shall be monitored by DDC Controller.

- | | |
|-------------------------------|--|
| • AHU _x RAT_T | - Return Air Temp (1 AI) |
| • AHU _x HTGVLV_MOD | - Heating Coil Valve Modulation (1 AO) |
| • AHU _x HTGPMP_CMD | - Heating Coil Pump Start/Stop (1 DO) |
| • AHU _x HTPGMP_STS | - Heating Coil Pump Status (1 DI) |
| • AHU _x CLGVLV_MOD | - Cooling Coil Valve Modulation (1 AO) |
| • AHU _x FRZ_ALM | - Freeze Stat Status – (1 DI) |

Note: The Freeze Stat should be DPDT hardwired to shut down VSD's and disable power to actuators. The second set of contacts is to be monitored by DDC Controller.

.2 Start/Stop:

- .1 The EMCS shall enable the fan system to start when commanded on through either MOS_x or other specified modes of operation. When commanded on, the supply fan shall start first and ramp up to a speed of 25%. Once the supply fan status is proven on (through speed feedback), the EMCS will start the return fan and ramp the fan speed up to 25%. Once the return fan is proven on (through speed feedback), the unit will be allowed to operate under VSD control.
- .2 Starting value of 25% output and a ramp duration of 120 seconds, the VSD supply and return fan speeds shall increase together by 1% increments until the minimum duct static pressure set-point has been reached. Once the duct static pressure set point has been reached, Fan speed control for variable volume sequence shall take over.
- .3 If either fan fails to prove flow, an alarm will be sent to the EMCS.
- .4 When the EMCS sends the signal to stop; both fans shall stop, mixed air dampers shall close to full re-circulation, heating and cooling valves shall return to their fail-safe position.

.3 Fan Speed Control for Variable Volume:

- .1 The EMCS will modulate the supply fan variable speed drive to maintain the Supply air static pressure set-point (SADSP_SPT) of 1.2" WG (adjustable) from a sensor located approximately 2/3 of the way downstream of the fan. The EMCS will modulate the return fan VSD to maintain a fixed differential between the supply fan

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speed and the return fan speed. This differential will be coordinated with the air balance contractor for proper building pressurization or as set-up by the CA during commissioning.

.4 Mixed Air/Supply Air Temperature Control

- .1 During occupied operation of the unit the EMCS shall modulate the mixed air dampers (MADPR) between minimum ventilation and 100% outside air, in sequence with the cooling coils to maintain the supply air set- point (SAT_SPT). SAT_SP shall be reset from the return as follows:

Return Air Temp RAT-T	Supply Air Temp Set-point SAT_SPT
20°C (adjustable)	18°C (adjustable)
24°C (adjustable)	13°C (adjustable)

- .2 The mixed air low limit set-point (MAT-LLSPT) shall override the mixed air dampers to maintain a minimum temperature of 6.6°C (adjustable and displayed on system graphics).
- .3 The economizer control strategy shall incorporate a single economizer enable/disable control point (ECOS) and economizer set-point (ECON-SPT).
- .4 The economizer control shall be disabled when the outdoor temperature rises above 18oC (64°F – Adjustable) or whenever the chiller is running, and mechanical cooling is available. The mixed air dampers shall close to minimum ventilation position.

.5 Safeties

- .1 Low Temperature Protection Control: When air temperature downstream of the heating coil drops below 5°C (40°F - adjustable, as sensed by low limit (DPDT) freeze stat), the supply and return fans VSD's will shut down, outdoor air dampers will close and return air damper will open, the cooling coil valve will open to full flow to the coil. A maintenance alarm will be generated. The freeze stat will need to be manually reset for normal operation to resume.
- .2 High Duct Static Pressure: Upon detection of high duct static pressure from the supply static pressure switch the supply and return fans VSD's will cycle off, the outdoor air and exhaust dampers will close, and a Maintenance Alarm will be generated. Once the static pressure switches are reset, the unit will return to normal control.
- .3 Fire Alarm Fan Shutdown: Where Fire Alarm interlocks exist, the EMCS shall not restrict the fire alarm system from shutting down all fans on a fire alarm condition (with starter in either hand or auto position). Where FA panel is monitored by EMCS< upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.

.6 Alarms

.1 Critical

- .1 None

.2 Environmental

- .1 Fan Status vs Command
- .2 Supply, Mixed, Return Air, High and Low Limits

.3 Maintenance

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- .1 Freeze Stat Alarm
- .2 High Duct Static Pressure Alarm
- .3 Heating Coil Pump Status Off Below 5oC(Adjustable)
- .4 Mixed air dampers operating below the Minimum Ventilation setting for more than 2 minutes (adjustable)
- .5 When OAT< 0oC (adjustable) and mixed air dampers operating above the minimum setting for more than 2 minutes (adjustable)
- .6 Differential between Modulation Signal and Speed Feedback greater than 5% for more than 5 minutes (adjustable)
- .4 **Energy Alarms**
 - .1 Fan Status On for more than 2 hours cumulatively (adjustable) during un-occupied (NSB) operation.
 - .2 Fan system operating in Occupied Mode outside of Originally Scheduled MOSx
 - .3 VFD Modulation greater than 80% (adjustable) for more than 2 hours cumulatively (adjustable) during occupied operation.
 - .4 The initial set up values for all alarms shall be established during the commissioning process.
- .7 Adjustable Points (to be displayed and accessed on system Setting Page)
 - Summer/Academic Schedules
 - Minimum Ventilation Setpoint
 - Supply Air/Return Air Reset Schedule Parameters
 - Mixed Air Temperature Low Limit (MATLL)
 - MATLL Time Delay
 - Economizer Setpoint (ECON_SPT)
 - Supply Air Duct Static Pressure set-point
 - Return Fan Speed Offset
 - Warm Weather Lockout Setpoint (Displayed, adjustable from Heating Plant Graphics
 - Alarm Settings – (setpoints and time delay parameters as noted in part 2.6.6 Alarms)

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2.7 VAV TERMINAL CONTROL

.1 Anticipated Points

- VAV###RMT_T - VAV Rm ### Space Temp (1 AI)
- VAV###RMT_SPT - Thermostat Temp Set Point (1 AI)
- VAV###OCC_STS - Occu Button/Sensor Status (1 DI)
- VAV###VP_PRS - VAV Velocity Pressure (1 AI)
- VAV###FLW_CFM - VAV Total Air Flow (1 AI)
- VAV###DPR_MOD - VAV Damper Modulation (1 AO)

Optional Reheat Points

- VAV###HTGVLV_MOD - VAV Htg Valve Modulation (1 AO)
- VAV###SAT_T - Supply Air Temp (1 AI)

.2 General:

- .1 The VAV terminal controller and room sensor shall be equipped with warmer/cooler set-point adjustment and override button (or Occupancy Sensor).
- .2 Each room (or zone) shall allow a fixed range of set-point adjustment 20oC to 22oC (Max Range +/-2°C from Set Point). The EMCS shall adjust the range, or the user may adjust, within this range, via the “Warmer/Cooler” selector on the thermostat.
- .3 Each room or space shall have the capability of an individual occupied/unoccupied schedule, which may be different from the AHU schedule, except that when AHU is in unoccupied operation mode; all rooms must also be in unoccupied mode.
- .4 All thermostats shall have an occupancy override button (and/or room occupancy Sensor). The EMCS shall enable the override button feature on an Owner defined basis, so that only Owner approved rooms and offices can utilize the override button feature.
- .5 A number of rooms and offices should be in occupied mode to assure that when AHU unit is energized it is meeting the manufacturer’s minimum airflow requirements.

.3 Occupied Operation Mode:

- .1 The VAV Terminal equipment controller (TEC) shall measure the room temperature and inlet duct velocity and modulate the VAV control damper through control logic to close the volume damper on decreasing room temperature and open the damper on increasing room temperature, to maintain room temperature set-point while providing pressure independent operation.
- .2 For VAV with heating coils, when the minimum primary air volume is reached and the room temperature continues to fall below the heating set-point, the heating valve shall start modulation to 100 % and then VAV will increase the air volume in order to meet the heating setpoint.
- .3 VAV Box Max and Min Airflow settings shall be per schedules on the drawings and verified by the TAB agent in coordination with EMCS contractor

.4 Unoccupied Operation Mode:

- .1 The AHU shall be de-energized. The VAV DDC controller shall switch to the unoccupied heating or cooling set-point of 18°C or 26.5°C, respectively (adjustable), and the VAV volume dampers shall be closed to a minimum position.

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- .2 If the space temperature falls outside the unoccupied range, the AHU may be activated. When the unoccupied heating mode is initiated at the AHU unit, the VAV DDC controller will measure room temperature and inlet duct velocity and shall modulate the VAV volume damper through control logic to open the damper on decreasing room temperature and close the damper on increasing room temperature. Otherwise the VAV shall operate similar to occupied mode.
- .5 Morning Start-up:
 - .1 Upon initiation of morning Start-up, room set-points are returned to Occupied Mode. If the EMCS determines the need for morning warm-up, all VAV controllers shall be set to 50% open and the room temperature sensors shall be switched to the occupancy mode. If the EMCS determines the need for morning cool-down or recirculation, the VAV boxes shall operate similar to occupied mode.
- .6 Safeties
 - .1 N/A
- .7 Alarms
 - .1 **Critical**
 - .1 Low Space Temperature Alarm
 - .2 **Environmental**
 - .1 Discharge Air, and Space Temperature; High and Low Limits
 - .3 **Maintenance**
 - .1 Discharge Air greater than 3oC (adjustable) above setpoint for more than 2 minutes (adjustable) – applies to units with reheat coils
 - .2 Space Temperature greater than 2oC above/below set point for greater than 5 minutes (Adjustable)
 - .3 Airflow higher/lower by 5% (adjustable) of airflow set point for greater than 5 minutes (adjustable)
 - .4 **Energy Alarms**
 - .1 During Occupied mode, control Damper command at 100% for greater than 5 minutes (adjustable).
- .8 Adjustable Points (to be displayed and accessed on system Setting Page)
 - Unoccupied heating/cooling setpoints
 - Occupied/Unoccupied Max/Min Airflow Settings
 - Alarm Settings – (setpoints and time delay parameters as noted in part 2.7.7 Alarms)

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2.8 MULTI ZONE AHU SYSTEM (INDOOR UNIT)

.1 Anticipated Points:

- AHU# SF_CMD - Supply Fan Start/Stop - (1 DO)
- AHU#SF_STS - Supply Fan Status - (1 DI)
- AHU# RF_CMD - Return Fan Start/Stop - (1 DO)
- AHU# RF_STS - Return Fan Status - (1 DI)
- AHU# MAT_T - Mixed Air Temp- (1 AI)
- AHU# RAT_T - Return Air Temp- (1 AI)
- AHU#MADPR_MOD -Mixed Air Damper Modulation- (1AO)
- AHU#HTGVLV_MOD -Htg Valve Modulation- (1AO)
- AHU#HTGSAT_T - Hot Deck Temp- (1 AI)
- AHUxHTGPMP_CMD - Heating Coil Pump CMD (1 DO)
- AHUxHTGPMP_STS - Heating Coil Pump Status (1 DI)
- AHUxFRZ_ALM - Freeze Stat Status – (1 DI)

Note: The Freeze Stat should be DPDT hardwired to Shut down SF1 & RF1 and disable power to actuators. The second set of contacts is to be monitored by DDC Controller.

- AHUxCLGVLV_MOD - Cooling Coil Valve Modulation (1 AO)
- or
- AHUxCLG1_CMD - Cooling Coil DX Stage (1 DO)
- AHU#CLGSAT_T - Cold Deck Temp - (1 AI)
- AHU#ZN#DPR_MOD - AHU Zone# Damper Modulation- (1 AO)
- AHU#ZN#SAT_T - Zone # Supply Air Temperature (1AI)
- AHU#ZN#RMT_T - Zone # Space Temp (1 AI)
- AHU#ZN#RMT_SPT - Zone # Space Temp Set Point (1 AI)
- AHU#ZN#OCC_STS - Zone # Occu Button/Sensor Status (1 DI)

.2 Start/Stop:

- .1 The EMCS shall enable the fan system to start when commanded on through either MOSx or other specified modes of operation. When commanded on, supply fan shall start first. Once the supply fan status is proven on, the EMCS shall start the return fan. Once return fan status is proven the EMCS shall allow application of the specified mixed air, heating and cooling sequences. (Note: Where fans are hard wire interlocked – both shall be started simultaneously).
- .2 When the EMCS sends the signal to stop; both fans shall stop, mixed air dampers shall close to full re-circulation, heating and cooling valves shall return to their fail-safe position.

.3 Mixed Air Control

- .1 During occupied operation, the minimum outdoor air damper shall open first, and the mixed air dampers shall modulate to maintain the cold deck set-point, with a mixed air low limit (MAT-LL) of 6°C. (adjustable).
- .2 The economizer control strategy shall incorporate a single economizer enable/disable control point and economizer set-point (ECON-SPT).
- .3 The economizer control shall be disabled when the outdoor temperature rises above 18oC (adjustable) or whenever the chiller is running and/or mechanical cooling is available

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- .4 If the outdoor temperature rises above Economizer set point (ECON-SPT) and the mechanical cooling is available, the mixed air dampers shall close to 20% (adjustable) minimum position.

- .4 Hot Deck Control

- .1 During occupied operation, the hot deck set-point shall be reset according to the following (adjustable) schedule:

Zone Space Temp	Hot Deck Temp Set-point
18.0°C (adjustable)	45°C (adjustable)
22.0°C (adjustable)	28°C (adjustable)

- .2 The EMCS shall modulate the heating control valve (or gas burner) to maintain the hot deck temperature set-point. The hot deck set point shall be further reset by heating demand as follows:

- .1 If maximum hot deck zone damper position is more than 85% open to hot deck, the hot deck calculated set-point shall be offset in 0.5°C increments to a maximum of SPT+5°C, which means that the zone with the greatest heating demand will increase the hot deck temperature set-point.
 - .2 If the maximum hot deck zone damper position is less than 60% open to hot deck, the hot deck temperature set-point shall be offset by -0.5°C to a minimum of SPT-5°C.
 - .3 The calculated (active) set point shall be displayed with the reset schedule on the system graphics.
 - .4 When the Air Handling Unit is OFF, the heating valve shall continue to modulate (for gas fired unit the burner shall remain off).

- .5 Cold Deck Control

- .1 During occupied operation, the cold deck set-point shall be reset based on cooling demand as follows:

- .1 If the maximum cold deck zone damper is more than 80% open to cooling, the cold deck temperature set-point shall be decreased slowly in 0.5°C increments to a minimum cooling set point of 13°C (adjustable), which means that the zone with the maximum cooling demand shall decrease the cold deck temperature set-point.
 - .2 If the maximum cold deck zone damper position is less than 60% open, the cold deck temperature set-point shall be increased in 0.5°C increments to a maximum of 18°C.
 - .3 When the outside temperature is below 16.5°C, the mixed air dampers shall be modulated to maintain the cold deck set-point. If the outside temperature is more than 18°C, the EMCS shall modulate the cooling control valve to maintain the cold deck temperature set-point and the mixed air dampers shall be closed to the minimum fresh air position.

- .6 Zone Damper and Temperature Control

- .1 The cold and hot deck zone dampers shall modulate in sequence to maintain individual zone temperature cooling and heating set-points.
 - .2 If the space temperature associated with the zone control is also controlling a radiation valve for the same area, the EMCS shall modulate first the zone damper to 100%

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heating open position. If the heating set-point is not satisfied, the EMCS shall start to modulate the radiation valve to meet the heating requirements.

.3 Occupied mode set-points:

- Space heating set-point: 21.5°C (adjustable)
- Space cooling set-point 24.5°C (adjustable)
- Minimum dead band 2.5°C (adjustable)

.4 Unoccupied mode set-points

- Space heating set-point: 18°C (adjustable)
- Space cooling set-point 26°C (adjustable)
- Minimum dead band 2.5°C (adjustable)

.5 Where applicable, occupancy sensors shall be used to detect vacancy of zones during occupied operation as follows:

- .1 If the zone is vacant for a period of 15 minutes (adjustable) the associated zone shall be “un-occupied” and not include in the reset of Hot/Cold deck algorithms.

.7 Safeties

- .1 Low Temperature Protection Control: When air temperature downstream of the heating coil drops below 5°C (40°F - adjustable, as sensed by low limit (DPDT) freeze stat), the supply and return fans will shut down, outdoor/exhaust air dampers will close and return air damper will open, the heating coil valve will open to full flow to the coil. A maintenance alarm will be generated. The freeze stat will need to be manually reset for normal operation to resume.
- .2 High Temperature Protection Control: If high temperature limit rises above the setting of 60oC or 140oF the supply and return fans shall shut down. Once the high temperature protection control has been manually reset, the unit will return to normal control.
- .3 Fire Alarm Fan Shutdown: Where Fire Alarm interlocks exist, the EMCS shall not restrict the fire alarm system from shutting down all fans on a fire alarm condition (with starter in either hand or auto position). Where FA panel is monitored by EMCS< upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.

.8 Alarms

.1 **Critical**

- .1 Low Room Temperature

.2 **Environmental**

.3 Fan Status vs Command

.4 Cold/Hot Deck Supply, Mixed, and Return Air High and Low Limits

.5 **Maintenance**

- .1 Freeze Stat Alarm
- .2 Heating Coil Pump Status Off Below 5°C(Adjustable)
- .3 Mixed air dampers operating below the Minimum Ventilation setting for more than 10 minutes (adjustable)
- .4 When OAT< 0oC (adjustable) and mixed air dampers operating above the minimum setting for more than 2 minutes (adjustable)
- .5 Compressor Failure Alarm (when monitored)

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- .6 Cold Deck Temperature below 9oC for more than 5 minutes (adjustable)
- .7 Mixed air temperature below MAT-LL SPT for more than 5 minutes (adjustable)
- .8 Zone Temperature below setpoint by more than 3oC for more than 15 minutes (adjustable)
- .6 **Energy Alarms**
 - .1 Fan Status On for more than 2 hours cumulatively (adjustable) during un-occupied (NSB) operation.
 - .2 Fan system operating in Occupied Mode outside of Originally Scheduled MOSx
- .7 Alarm condition initial set up values to be established during the commissioning process.
- .9 Adjustable Points (to be displayed and accessed on the System Setting Page)
 - Summer/Academic Schedules
 - Mixed Air Temperature Low Limit (MATLL)
 - MATLL Time Delay
 - Hot Deck & Cold Deck Reset Schedule Parameters
 - Economizer Setpoint
 - Minimum Ventilation
 - Unoccupied Heating Set Points
 - Zone Vacancy Period (15 min)
 - Alarm Settings – (setpoints and time delay parameters as noted in part 2.8.8 Alarms).

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2.9 PACKAGED ROOFTOP UNITS (NO BACNET)

- .1 Anticipated Points
 - RTUxFAN_CMD – Fan Start/Stop – (1 DO)
 - RTUxSF_STS – Supply Fan Status – (1 DI)
 - RTUxECONDIS_CMD - Economizer Disable – (1 DO)
 - RTUxSAT_T - Supply Air Temp - (1-AI)
 - RTUxRAT_T - Return Air Temp - (1-AI)
 - RTUxMAT_T - Mixed Air Temp - (1-AI)
 - RTUxHTG1_CMD - Heating Stage 1 Command - (1-DO)
 - RTUxHTG2_CMD - Heating Stage 2 Command - (1-DO)
 - RTUxCLG1_CMD - Cooling Stage 1 Command - (1-DO)
 - RTUxCLG2_CMD - Cooling Stage 2 Command - (1-DO)
 - RTUx4CLG1_STS - Cooling Stage 1 Status - (1-DI)
 - RTUx4CLG2_STS - Cooling Stage 2 Status - (1-DI)
 - RTUxRM###_SPT - Room # Room Temp Setpoint (1-AI)
 - RTUxRM###_T - Room # Room Temp (1-AI)
 - RTUxRM###_OCC - Room # Occ Sensor/Button Status (1-DI)
- .2 Start/Stop:
 - .1 The EMCS shall enable the rooftop unit fan to start when commanded on through MSOSx or other specified modes of operation (Night Purge, Morning Warm-Up, Night Setback).
 - .2 When commanded on in occupied mode, the supply fan shall operate continuously with heating, cooling or economizer cooling to maintain the occupied set points.
 - .3 During un-occupied operation, the supply fan shall remain off unless required to satisfy un-occupied heating and cooling set points or for night purge/morning warm-up mode.
- .3 Heating/Cooling/Ventilation Control:
 - .1 During occupied mode, the EMCS shall enable the dampers the Economizer disable command (ECONDIS_CMD) allowing the RTU to operate the mixing dampers between a fixed minimum ventilation setting and full economizer cooling.
 - .2 Heating and Cooling demand shall be determined by the room temperature setpoint (RM###RMT_SPT). Users shall have an adjustable thermostat with a range of +/- 2oC or for public areas there shall be a flat plate sensor and Occupied Heating/Cooling Setpoint shall be established by the Facility Operator through the Settings page. Heating and Cooling set-point shall be established based on a deadband of set-point +/-1oC (adjustable via settings page)
- .4 Cooling Mode:
 - .1 When the room temperature rises to RMT_SPT +1oC the first stage of cooling shall be energized. The on-board RTU controls will determine if outdoor temperature is below the economizer set point (free cooling mode) or if mechanical cooling (DX) shall be activated.
 - .2 When the room temperature reaches RMT_SPT, cooling shall be deactivated.
- .5 Heating Mode:

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- .1 If the room temperature falls to RMT_SPT-1°C, (when present) the room convector shall act as the first stage of heating and shall modulate to maintain RMT_SPT. If RMT_SPT falls to RMT_SPT -1.5°C, the first stage of mechanical heating shall be enabled.
- .2 If the room temperature falls to RMT_SPT-2°C, the second stage of heating shall be enabled.
- .3 When the room temperature reached RMT_SPT-1.5°C, the second stage of heating shall be deactivated.
- .4 When the room temperature reaches RMT_SPT the first stage of heating shall be deactivated.
- .6 Night Set-Back Control:
 - .1 During un-occupied operation, the fan system shall remain off unless the space temperature falls below the night set-back temperature of 18°C (adjustable).
 - .2 When the space temperature falls to NSB_SPT -0.5°C, the fan system shall be enabled with the perimeter heating valve acting as the source of heat and shall operate until the space temperature reaches NSB_SPT +1.0°C. The fan system will then shut off until the next cycle.
 - .3 During on-occupied and night set-back modes, the dampers shall be commanded “off” (ECONDIS_CMD) and will remain closed to 0% outdoor air (full return air). Where present, the perimeter heating valve shall continue to modulate to maintain NSB_SPT +1°C.
- .7 Safeties
 - .1 Mechanical Cooling Lock Out (Low Ambient). When the outside temperature is less than on board RTU Ambient cooling lock-out set point (typically 12°C) the compressor shall not be allowed to run
 - .2 Anti-Short Cycle Timer. Minimum run times for the cooling shall be provided to prevent short cycling and avoid compressor failure.
 - .3 Fire Alarm Fan Shutdown: The fire alarm system may shut down all fans on a fire alarm condition. Upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.
- .8 Alarms
 - .1 **Critical**
 - .1 Low Room Temperature
 - .2 **Environmental**
 - .1 Fan Status vs Command
 - .2 Supply, Return Air High & Low Limits
 - .3 **Maintenance**
 - .1 Discharge Air greater than 3°C (adjustable) above setpoint for more than 2 minutes (adjustable).
 - .2 Supply Air Temperature <8°C(adjustable) when OAT<5°C for more than 2 minutes (adjustable)
 - .3 Burner Failure
 - .4 Fan Failure

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.4 Energy

- .1 Fan Status On for more than 2 hours cumulatively (adjustable) during un-occupied (NSB) operation.
- .2 Fan system operating in Occupied Mode outside of Originally Scheduled MSOSx
- .3 The initial set up values for all alarms shall be established during the commissioning process.

.9 Adjustable Points (to be displayed on system Setting Page)

- Operating Schedules
- Unoccupied Heating/Cooling SP
- Supply Air Low Limits
- Occupied Heating/Cooling deadbands
- Alarm Settings – (setpoints and time delay parameters as noted in 2.9.8 Alarms)

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2.10 ROOFTOP UNIT WITH BACNET INTERFACE CARD

- .1 Anticipated Points
 - RTUxBACNET_COM RTUx BACNet Communications (COM)
- .1 Virtual Read/Write Points are vendor and product dependant and will be determined during the individual project design phase process. Some of these points will including but not limited to: Occupied/Unoccupied Heating/Cooling Setpoints, Occupied/Unoccupied Command, Minimum Ventilation Setting, Heating Demand, Cooling Demand, Supply Air Temperature, Space Temperature, Return Air Temperature, Return Air Humidity, Return Air/space CO2, Compressor Status, Fan Status, Fan Speed, etc.
- .2 General
 - .1 The OEMASC should be BACNet Certified Open controller that comes as an integrated component of a Rooftop unit. Its internal application programing is designed to provide optimum Rooftop performance and energy efficiency. The RTU OEMASC enables the unit to run 100% stand-alone control mode or it can communicate to the EMCS via BACnet (typically via DIP switch settings on the On-Board Controller which also allowing User to select the baud rate for the associated communication protocol.
 - .2 The OEMASC generally operates by using set points in and out of service. This method consists of BACnet objects that the EMCS can access to control and monitor the status of the rooftop units.
 - .3 It is important to define the amount of control that the EMCS system will apply to the unit. This can be done by configuring the OEMASC with the RTU manufacturer's technician.
- .3 Operation Modes
 - .1 The rooftop unit shall operate in Four (4) specific modes of operation according to user adjustable (TOD) time of day schedules as follows:
 - .1 Occupied Mode: The EMCS shall send a signal to the OEMASC commanding "Occupied Operation".
 - .2 Unoccupied Mode: When in unoccupied mode, the unit shall remain off unless duty cycled in order to maintain un- occupied heating/cooling set-points with minimum ventilation set to 0%.
 - .3 Optimized Start Mode: The RTU OEMASC shall operate on the EMCS based optimized time schedules. During the warm-up mode, the rooftop unit shall operate on full return air with heating enabled to reach the daytime occupied heating setpoint.
 - .4 Night Purge Mode: The night purge control strategy uses outside air to pre-cool the building before the occupancy mode and mechanical cooling is turned ON. The outdoor air and space temperature and RH relative humidity shall be analyzed by the EMCS. When conditions are met, the EMCS shall enable the unit with 1st stage cooling to allow for fresh-air to purge the space prior to the start of the occupied day.
 - .5 The following conditions apply:

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- Outdoor air temperature is above the Heating/Cooling changeover setpoint of 13°C (adjustable).
 - The outside dry bulb temperature is below space temperature.
 - Outside relative humidity is below the 16°C dew point.
- .4 Active Ventilation Control Option.
- .1 Optional CO2 sensors may be supplied by the Rooftop unit Manufacturer. During Occupied Mode, EMCS shall send a signal to the OEMASC for setting the CO2 control set-point to 1100 ppm (adjustable).
 - .2 If the measured CO2 is 900 ppm or less, the minimum ventilation setting shall be 10% (adjustable). If the CO2 level reading rises above 900 ppm, the OEMASC shall increase the minimum ventilation to a maximum “minimum Ventilation” setting of 30% (adjustable).
- .5 Power Exhaust & Building Static Pressure Control
- .1 Rooftop units (10 Tons and over) are equipped with a constant speed power exhaust fan and barometric relief dampers with a limiter control arm (or optional VFD on the fan).
 - .2 The OEMASC controller monitors the fresh air damper position to determine when the power exhaust fan is to be enabled/disabled utilizing an on-board building static pressure sensor to adjust the limiter arm position (or control the speed of the fan).
 - .3 The EMCS shall send a control signal to the OEMASC to adjust the exhaust fan enable air setting and the building static pressure set point through a user adjustable setting on the graphics.
- .6 Heating & Cooling Control
- .1 The EMCS shall monitor the space temperature through the OEMASC and shall display it on the system graphics page. On the settings page the EMCS shall display the adjustable Heating & Cooling set points with the associated dead bands in order to avoid simultaneous heating and cooling.
- .7 Safeties
- .1 Mechanical Cooling Lock Out (Low Ambient). When the outside temperature is less than on board RTU Ambient cooling lock-out set point (typically 12oC) the compressor shall not be allowed to run
 - .2 Anti-Short Cycle Timer. Minimum run times for the cooling shall be provided to prevent short cycling and avoid compressor failure.
 - .3 Fire Alarm Fan Shutdown: The fire alarm system may shut down all fans on a fire alarm condition. Upon clearing all fire alarms the EMCS shall start all the fans in a staggered manner to prevent excessive power demand.
- .8 Alarms
- .1 **Critical**
 - .1 Low Room Temperature
 - .2 **Environmental**
 - .1 Fan Status vs Command
 - .2 Supply, Return Air High & Low Limits
 - .3 **Maintenance**

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- .1 Discharge Air greater than 3°C (adjustable) above setpoint for more than 2 minutes (adjustable).
- .2 Supply Air Temperature <8°C(adjustable) when OAT<5°C for more than 2 minutes (adjustable)
- .3 Burner Failure
- .4 Fan Failure
- .4 **Energy**
 - .1 Fan Status On for more than 2 hours cumulatively (adjustable) during un-occupied (NSB) operation.
 - .2 Fan system operating in Occupied Mode outside of Originally Scheduled MSOSx
- .5 The initial set up values for all alarms shall be established during the commissioning process.
- .9 Adjustable Points (to be displayed on system Setting Page)
 - Operating Schedules
 - Unoccupied Heating/Cooling SP
 - Minimum Ventilation Settings
 - CO2 Setpoint
 - Building Static pressure setpoint
 - Power Exhaust Enable Set point
 - Supply Air Low Limits
 - Occupied Heating/Cooling deadbands
 - Alarm Settings – (setpoints and time delay parameters as noted in 2.10.8 Alarms)

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2.11 ARENA DEHUMIDIFIER

.1 Associated Points

- DHxSF_STS - Supply Fan Status (1DI)
- DHxRF_STS - Return Fan Status (1DI)
- DHxERW_STS - Energy Recovery Wheel Status (1DI)
- DHxSAT_T - Supply Air Temp (1AI)
- DHxRAT_T - Return Air Temp (1AI)
- DHxEAT_T - Exhaust Air Temp (1AI)
- DHxENA_CMD - Dehumidifier Enable Command (1DO)
(Typical 2 pad system)
- PADxCO_LVL - Pad X CO Level (2 AI)
- PADxRMT_T - Pad X Room Temperature (2AI)
- PADxHUM_LVL - Pad X Humidity Level (2AI)
- PADxEF_CMD - Pad X Exhaust Fan Command (2DO)
- PADxEF_STS - Pad X Exhaust Fan Status (2DI)
- PADxFADPR_CMD - Pad X Fresh Air Damper Command (2DO)
- PADxFADPR_STS - Pad X Fresh Air Damper Status (2DI)

.2 Start/Stop:

- .1 The EMCS shall enable the dehumidification system to operate when commanded on through MSOSx and based on seasonal operating schedule
- .2 All control functionality shall remain with the unit mounted OEMASC. The EMCS vendor is to interface with an existing terminal strip within the unit to monitor status of unit operation.

.3 Arena Exhaust Fan and Intake Dampers Controls:

- .1 The EMCS shall monitor CO levels in the arena
- .2 When the CO levels rise above the setpoint, the EMCS shall open the Fresh Air Intake Damper. When the end switch on this damper closes the EMCS shall command the Exhaust Fan ON
- .3 When CO levels drops 9 ppm below the CO setpoint, the EMCS shall command the exhaust fan OFF and close the associated damper
- .4 If the CO level rises above the CO alarm level limit, a critical alarm shall be generated

.4 Humidity Controls

- .1 The EMCS is to monitor temperature and humidity in the Arena space and send a signal to DH-1 when humidity rises above the humidity setpoint.
- .2 All other controls are to remain with the unit mounted OEM controller. The EMCS vendor is to interface with an existing terminal strip within the unit to monitor status of unit operation.

.5 Safeties:

- .1 N/A

.6 Alarms

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City of Mississauga - Typical Points List & Standard Sequences of Operation

- .1 **Critical**
 - .1 High CO Level
- .2 **Environmental**
 - .1 High RH Level
 - .2 Other TBD (based on what is available from OEMASC BacNet)
- .3 **Maintenance**
 - .1 TBD (based on what is available from OEMASC BacNet)
- .4 **Energy**
 - .1 TBD (based on what is available from OEMASC BacNet)
- .7 Adjustable Points (to be displayed on system Setting Page)
 - Operating Schedules
 - CO Level Setpoint
 - RH Setpoint
 - RH Deadbands
 - Alarm Settings – (setpoints and time delay parameters as noted in 2.11.6 Alarms)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

2.12 MISCELLANEOUS EXHAUST FANS

- .1 Anticipated Points:
 - WREFx-CMD -Washroom Exhaust Start/Stop (1 DO)
 - WREFx-STS -Washroom Exhaust Status (1 DI)
- .2 Start/Stop:
 - .1 The EMCS shall enable the exhaust fan(s) to start when commanded on through an associated MSOSx or for a programmed event.
 - .2 At all other times the exhaust fan(s) shall be scheduled OFF.
 - .3 If equipped with an isolating damper, on a command from the EMCS, the exhaust damper shall open and when the end switch makes, the fan shall start, and the damper status shall be available at EMCS.
- .3 Safeties:
 - .1 N/A
- .4 Alarms:
 - .1 **Critical**
 - .1 N/A
 - .2 **Environmental**
 - .1 N/A
 - .3 **Maintenance**
 - .1 Command ON – Status OFF
 - .4 **Energy**
 - .1 Command OFF – Status ON
 - .2 The initial set up values for all alarms shall be established during the commissioning process.
- .5 Adjustable Points (to be displayed and accessed on system Setting Page)
 - Schedules
 - Alarm Settings – (setpoints and time delay parameters as noted in part 2.12.4 Alarms)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

2.13 TWO (2) CONDENSING BOILERS CONTROL STRATEGY

.1 Anticipated Points:

BOILER 1

- BLR1ENA_CMD -Boiler 1 Enable/Disable (1 DO)
- BLR1SWT_T -Boiler 1 Supply Water Temp (1 AI)
- BLR1BUR_MOD -Boiler 1 Burner Modulation (1 AO)
- BLR1ALM_ALM -Boiler 1 Alarm Status (1 DI)
- BLR1MOD_FBK -Boiler 1 Modulation Feed Back (1 AI)
- BLR1CPMP_STS -Boiler 1 Circulation Pump Status (1 DI)

BOILER 2

- BLR2ENA_CMD -Boiler 2 Enable/Disable (1 DO)
- BLR2SWT_T -Boiler 2 Supply Water Temp (1 AI)
- BLR2BUR_MOD -Boiler 2 Burner Modulation (1 AO)
- BLR2ALM_ALM -Boiler 2 Alarm Status (1 DI)
- BLR2MOD_FBK -Boiler 2 Modulation Feed Back (1 AI)
- BLR2CPMP_STS -Boiler 2 Circulation Pump Status (1 DI)

COMMON SYSTEM POINTS

- BLDGOAT_T -Building Outdoor Air Temperature (1 AI)
- MHWST_T -Main Heating Water Supply Temperature (1AI)
- MHWRT_T -Main Heating Water Return Temperature (1AI)
- MHTGPMP1_CMD -Main Heating Pump 1 Enable/Disable (1DO)
- MHTGPMP1_STS -Main Heating Pump 1 Status (1DI)
- MHTGPMP2_CMD -Main Heating Pump 2 Enable/Disable (1DO)
- MHTGPMP2_STS -Main Heating Pump 2 Status (1DI)

.2 Start/Stop

- .1 The Heating System shall be enabled by the EMCS when the outside air temperature is 1oC below WWLO-SP (15°C adjustable) and disabled when the outdoor air temperature rises 1oC above the WWLO-SP as follows:
 - .1 When the Heating System has been enabled, the primary heating pumps and coil circulators shall be switched on first, after a 3-minute delay and at minimum one (1) pump status verification the boilers shall be allowed to operate in accordance to the specified Boiler control sequence.
 - .2 When the heating system has been disabled, the boilers shall be shut off first, and after a 3-minute time delay all primary pumps and coil circulators shall be switched off.
 - .3 Heating pumps with one operational and one standby shall operate as Lead/Lag operation. The “Lead” shall be rotated on a weekly basis (every Tuesday at 8am) with graphical indication as to which pump is Lead and which is Lag. If the lead pump status is off, the lag pump shall be started within 3 seconds. If the primary pump status returns to “on”, both pumps shall operate for 2 minutes before the standby pump is shut off. When switching New primary pump shall be started and status proven before standby (old primary) pump is switched off.

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City of Mississauga - Typical Points List & Standard Sequences of Operation

- .4 When an individual boiler is commanded off, the associated boilers circulated shall continue to run for 3 minutes to dissipate heat and then will shut off (internal to boilers).
 - .5 The boilers shall operate as Lead/Lag operation. The “Lead” shall be rotated on a weekly basis (every Tuesday at 8am) with graphical indication as to which boiler/pump is Lead and which is Lag. If the lead boiler is in Alarm or status has not been verified within 3 minutes (adjustable) after enable, the lag boiler shall become the lead boiler and a maintenance alarm shall be generated.
 - .6 When the heating system has first be enabled through the WWLO_SPT and the primary heating water pump has operated for 3 minutes, the lead boiler and associated circulation pump should be turned ON at high fire, once status is proven the burner shall be allowed to modulate. After Lead Boiler burner status has been proven and boiler command is at 100% for 10 minutes (adjustable), the lag boiler shall be enabled at high fire. Once the lag boiler burner status has proven, both boilers shall be allowed to modulate together on the same command signal.
 - .7 Both boilers shall be operated together until the Main Heating Water Supply Temperature setpoint (MHSWT-SPT) has been satisfied and then normal boiler sequence of operation shall begin.
- .3 Boiler Control
- .1 When the main heating water supply temperature (MHWST_T) is more than 2.5°C (Adjustable) below set point (MHWST_SP) the lead boiler shall be commanded ON by the EMCS, followed by burner modulation. The burner shall first be enabled at low fire, 3 Minutes (adjustable) after Burner Status is proven the burner shall be allowed to gradually increase output using PID control to maintain the heating system set point (MHSWT_SP).
 - .2 If the MHWST_T falls to more than 8.5°C (User Adjustable) below the MHWST_SP, and the lead boiler is burner modulation is at 90% or greater output, the lag boiler (and associated circulation pump) shall be commanded “ON” and held at low fire while The lead boiler continues to modulate according to its PID loop to maintain MHWST_SP.
 - .3 When the lag boiler Burner Status has proven there shall be a 3 minute (adjustable) time delay followed stepped control of burner (increases in increments of 5% output every 2 minutes) until reaching 50% output or until the lead boiler output command falls to 60% modulation output or lower. When either of these conditions are met, both boilers (lead and lag) shall go to low fire and then be allowed to modulate together to satisfy the MHWST_SP.
 - .4 When the MHWST_T reaches set point, the lag boiler shall be disabled, and the lead boiler shall continue to modulate. When the MHWST_T rises to set point + 3oC, the lead boiler shall hold at minimum fire. When at low fire, if the MHWST_T reaches set point + 5oC the lead boiler shall be switched off. If the MHWST_T drops to set point - 1oC the boiler may begin to modulate again according to the PID loop command.
- .4 Hot Water Supply Reset
- .1 The outside air temperature reset schedule shall reset the heating water supply temperature set-point (MHWST_SP) according to the following schedule:

Outdoor Air Temp

Hot Water Supply Temp

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City of Mississauga - Typical Points List & Standard Sequences of Operation

OAT-T
-15°C
10°C

MHWST SP
80°C
35°C

- .2 All parameters of the reset schedule shall be (super used) adjustable through the graphics. The indoor/outdoor reset schedule shall also be offset by actual heating demand and the calculated setpoint shall be displayed on the system graphics.
- .5 Heating Demand Offset
 - .1 Actual heating demand shall be measured by available (site specific) conditions including but not limited to the following:
 - Perimeter Heating Demand (1-2 classrooms per zone or the zone 3-way valve).
 - AHU Heating Valve Demand (AHU with greatest heating demand)
 - Condenser Water Loop Heating Valve Demand
 - .2 If all of the heating valves are less than 60% heating demand, decrease the MHWST_SP by 1°C every 2 minutes to a maximum of MHSWT-SP -7.5°C. This shall be considered the ACTIVE MHSWT-SP (displayed on the Graphics).
 - .3 If any of the heating valves have greater than 95% heating demand, increase the ACTIVE MHSWT_SP by 1°C every 2 minutes until reaching the original MHWST_SP or when the maximum heating demand is less than 70%.
- .6 Safeties
 - .1 When the boiler lead pump is commanded on by the EMCS, and no proof is received after 30 seconds, then the lead pump shall be commanded off and a maintenance alarm shall be generated. The lag pump shall start on failure of the lead pump. If the lag pump also fails, then a critical alarm shall be generated.
 - .2 A manual reset in programming shall be provided to release all pumps from emergency status and return to normal status and restart lead/lag sequence.
 - .3 The hot water return temperature for noncondensing boilers shall not be less than 48°C.
- .7 Alarms
 - .1 **Critical**
 - .1 Low Boiler Temp (MHWST<35°C when OAT<5°C)
 - .2 **Environmental**
 - .1 MHWST/MHWRT out of anticipated range.
 - .3 **Maintenance**
 - .1 Boiler failures/alarm
 - .2 Pump failure
 - .4 **Energy Alarms**
 - .1 Boiler cycles more than 4 times/hour (adjustable)
 - .2 Minimum Boiler operating time < 5 minutes (adjustable)
 - .5 The initial set up values for all alarms shall be established during the commissioning process.
- .8 Adjustable Points (to be displayed and accessed on system Setting Page)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

- Calendar Operating Schedule
- Outdoor/Supply Water Reset Schedule Parameters
- Lead Boiler Minimum Run Time
- Boiler Staging Differential Set Points and Lead/Lag Boiler Time Delays
- Warm Weather Lockout Setpoint and differential
- Alarm Settings – (setpoints and time delay parameters as noted in part 2.13.7 Alarms)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

2.14 THREE (3) CONDENSING BOILER CONTROL STRATEGY

.1 Anticipated Points:

BOILER 1

- BLR1ENA-CMD -Boiler 1 Enable/Disable (1 DO)
- BLR1SWT-T -Boiler 1 Supply Water Temp (1 AI)
- BLR1BUR-MOD -Boiler 1 Burner Modulation (1 AO)
- BLR1ALM-ALM -Boiler 1 Alarm Status (1 DI)
- BLR1MOD-FBK -Boiler 1 Modulation Feed Back (1 AI)
- BLR1CPMP-STC -Boiler 1 Circulation Pump Status (1 DI)

BOILER 2

- BLR2ENA-CMD -Boiler 2 Enable/Disable (1 DO)
- BLR2SWT-T -Boiler 2 Supply Water Temp (1 AI)
- BLR2BUR-MOD -Boiler 2 Burner Modulation (1 AO)
- BLR2ALM-ALM -Boiler 2 Alarm Status (1 DI)
- BLR2MOD-FBK -Boiler 2 Modulation Feed Back (1 AI)
- B2CPMP-STC -Boiler 2 Circulation pump Status (1 DI)

BOILER 3

- BLR3ENA-CMD -Boiler 3 Enable/Disable (1 DO)
- BLR3SWT-T -Boiler 3 Supply Water Temp (1 AI)
- BLR3BUR-MOD -Boiler 3 Burner Modulation (1 AO)
- BLR3ALM-ALM -Boiler 3 Alarm Status (1 DI)
- BLR3MOD-FBK -Boiler 3 Modulation Feed Back (1 AI)
- BLR3CPMP-STC -Boiler 3 Circulation Pump Status (1 DI)

Common points to all boilers:

- BLDGOAT-T -Building Outdoor Air Temperature (1 AI)
- MHWST-T -Main Heating Water Supply Temperature (1AI)
- MHWRT-T -Main Heating Water Return Temperature (1AI)
- MHTGPMP1-CMD -Main Heating Pump 1 Enable/Disable (1DO)
- MHTGPMP1-STC -Main Heating Pump 1 Status (1DI)
- MHTGPMP2-CMD -Main Heating Pump 2 Enable/Disable (1DO)
- MHTGPMP2-STC -Main Heating Pump 2 Status (1DI)

.2 Start/Stop

- 1 The Heating System shall be enabled by the EMCS when the outside air temperature is 1°C below WWLO-SP (15°C adjustable) and disabled when the outdoor air temperature rises 1°C above the WWLO-SP as follows:
 - 1 When the Heating System has been enabled, the primary heating pumps and coil circulators shall be switched on first, after a 3-minute delay and at minimum one (1) pump status verification the boilers shall be allowed to operate in accordance to the specified Boiler control sequence.
 - 2 When the heating system has been disabled, the boilers shall be shut off first, and after a 3-minute time delay all primary pumps and coil circulators shall be switched off.
- 2 Heating pumps with one operational and one standby shall operate as Lead/Lag operation. The “Lead” shall be rotated on a weekly basis (every Tuesday at 8am) with graphical indication as to which pump is Lead and which is Lag. If the lead pump status is off, the lag pump shall be started within 3 seconds. If the primary pump status

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City of Mississauga - Typical Points List & Standard Sequences of Operation

returns to “on”, both pumps shall operate for 2 minutes before the standby pump is shut off. When switching New primary pump shall be started and status proven before standby (old primary) pump is switched off.

- .3 When an individual boiler is commanded off, the associated boilers circulated shall continue to run for 3 minutes to dissipate heat and then will shut off (internal to boilers).
- .4 When there are three (3) boilers – (unless otherwise stated) two (2) are to be operational and one (1) shall always be standby. Lead, Lag and Standby Boilers shall be rotated on a weekly basis (every Tuesday at 6am) and graphically indicated as to which boiler is Lead, Lag and Standby. If either the Lead or Lag Boiler is in Alarm or status has not be verified within 3 minutes (adjustable) after enable command, the standby boiler shall replace that boiler as either Lead or Lag and a maintenance alarm shall be generated to indicate Boiler Failure. This standby boiler shall remain in rotation in the operating sequence until the alarm has been reset.
- .5 When the heating system has first be enabled through the WWLO_SPT and the primary heating water pump has operated for 3 minutes, the lead boiler and associated circulation pump should be turned ON at high fire, once status is proven the burner shall be allowed to modulate. After Lead Boiler burner status has been proven and boiler command is at 100% for 10 minutes (adjustable), the lag boiler shall be enabled at high fire. Once the lag boiler burner status has proven, both boilers shall operate together until the Main Heating Water Supply Temperature setpoint (MHSWT-SPT) has been satisfied and then normal boiler sequence of operation shall begin.

.3 Boiler Control

- .1 When the main heating water supply temperature (MHWST_T) is more than 2.5°C (Adjustable) below set point (MHWST_SP) the lead boiler shall be commanded ON by the EMCS, followed by burner modulation. The burner shall first be enabled at low fire, 3 Minutes (adjustable) after Burner Status is proven the burner shall be allowed to gradually increase output using PID control to maintain the heating system set point (MHSWT_SP).
- .2 If the MHWST_T falls to more than 8.5°C (User Adjustable) below the MHWST_SP, and the lead boiler is burner modulation is at 90% or greater output, the lag boiler (and associated circulation pump) shall be commanded “ON” and held at low fire while the lead boiler continues to modulate according to its PID loop to maintain MHWST_SP.
- .3 When the lag boiler Burner Status has proven there shall be a 3 minute (adjustable) time delay followed stepped control of burner (increases in increments of 5% output every 2 minutes) until reaching 50% output or until the lead boiler output command falls to 60% modulation output or lower. When either of these conditions are met, both boilers (lead and lag) shall go to low fire and then be allowed to modulate together to satisfy the MHWST_SP.
- .4 When the MHWST_T reaches set point, the lag boiler shall be disabled, and the lead boiler shall continue to modulate. When the MHWST_T rises to set point + 3oC, the lead boiler shall hold at minimum fire. When at low fire, if the MHWST_T reaches set point + 5oC the lead boiler shall be switched off. If the MHWST_T drops to set point - 1oC the boiler may begin to modulate again according to the PID loop command.

.4 Hot Water Supply Reset

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City of Mississauga - Typical Points List & Standard Sequences of Operation

- .1 The outside air temperature shall reset the heating water supply temperature set-point (MHWST_SP) according to the following schedule:

Outdoor Air Temp	Hot Water Supply Temp
OAT-T	MHWST SP
-15°C	80°C
10°C	35°C

- .2 All parameters of the reset schedule shall be (super used) adjustable through the graphics. The indoor/outdoor reset schedule shall also be offset by actual heating demand and the calculated setpoint shall be displayed on the system graphics.

.5 Heating Demand Offset

- .1 Actual heating demand shall be measured by available (site specific) conditions including but not limited to the following:
- Perimeter Heating Demand (1-2 classrooms per zone or the zone 3-way valve).
 - AHU Heating Valve Demand (AHU with greatest heating demand)
 - Condenser Water Loop Heating Valve Demand (where applicable)
- .2 If all of the heating valves are less than 60% heating demand, decrease the MHWST_SP by 1°C every 2 minutes to a maximum of MHSWT-SP -7.5°C. This shall be considered the ACTIVE MHSWT-SP (displayed on the Graphics).
- .3 If any of the heating valves have greater than 95% heating demand, increase the ACTIVE MHSWT_SP by 1°C every 2 minutes until reaching the original MHWST_SP or when the maximum heating demand is less than 70%.

.6 Safeties

- .1 When the boiler lead pump is commanded on by the EMCS, and no proof is received after 30 seconds, then the lead pump shall be commanded off and a maintenance alarm shall be generated. The lag pump shall start on failure of the lead pump. If the lag pump also fails, then a critical alarm shall be generated.
- .2 A manual reset in programming shall be provided to release all pumps from emergency status and return to normal status and restart lead/lag sequence.
- .3 The hot water return temperature for noncondensing boilers shall not be less than 48°C.

.7 Alarms

.1 **Critical**

- .1 Low Boiler Temp (MHWST<35oC when OAT<5oC)

.2 **Environmental**

- .1 MHWST/MHWRT High and Low Limits.

.3 **Maintenance**

- .1 Boiler failures/alarm
- .2 Pump failure

.4 **Energy Alarms**

- .1 Boiler cycles more than 4 times/hour (adjustable)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

- .2 Minimum Boiler operating time < 5 minutes (adjustable)
- .5 The initial set up values for all alarms shall be established during the commissioning process.
- .8 Adjustable Points (to be displayed and accessed on system Setting Page)
 - Calendar Operating Schedule
 - Outdoor/Supply Water Reset Schedule Parameters
 - Lead Boiler Minimum Run Time
 - Boiler Staging Differential Set Points and Lead/Lag Boiler Time Delays
 - Warm Weather Lockout Setpoint and differential
 - Alarm Settings – (setpoints and time delay parameters as noted in part 2.14.7 Alarms)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

2.15 PERIMETER RADIATION LOOP HEATING SYSTEM

- .1 Anticipated Points:
- | | |
|-------------------|------------------------------------|
| • HTGZxPMPx-CMD | - Heating Pump x CMD (1 DO) |
| • HTGZxPMP-STS | - Heating Pump x Status (1 DI) |
| • HTGZxHTGVLV-MOD | -Heating Valve Control (1 AO) |
| • HTGZxSWT-T | - Zone x Supply Water Temp (1 AI) |
| • HTGZxRWT-T | - Zone x Return Water Temp |
| • BLDGxOAT-T | - Building Outside Air Temp (1 AI) |
- Zone Controls
- Anticipated Points:
- | | |
|-------------------|---------------------------------------|
| • RMxxxRMT-T | - Room xxx Room Temp (1 AI) |
| • RMxxxHTGVLV_MOD | - Room xxx Htg Valve Modulation (1AO) |
- .2 Start/Stop:
- .1 The perimeter radiation loop pump(s) will be switched on/off according to the same parameters as specified in the Boiler Control Sequence.
- .3 Perimeter Radiation Control:
- .1 The radiation 3-way mixing valve shall be modulated based on the radiation zone heating water supply temperature set point (HTGZxSWT_SPT).
- .2 The outside air temperature shall reset the heating zone water supply temperature set-point (HTGZxSWT_SP) according to the following schedule:
- | Outdoor Air Temp
OAT-T | Zone Supply Water Temp
HTGZxSWT SP |
|---------------------------|---------------------------------------|
| -10°C | 75°C |
| 10°C | 40°C |
- .3 All parameters of the reset schedule shall be (super used) adjustable through the graphics. The indoor/outdoor reset schedule shall also be offset by actual heating demand within the associated zone and the calculated setpoint shall be displayed on the system graphics.
- .4 Heating Demand Offset
- .1 Actual heating demand shall be measured by available (site specific) room conditions within the zone including but not limited to the following:
- .1 Perimeter Heating Demand (Minimum 1-2 rooms per heating zone.
- .2 If the monitored heating valves are less than 60% heating demand, decrease the HTGZxSWT_SP by 1°C every 2 minutes to a minimum of HTGZxSWT_SP -10°C. This shall be considered the ACTIVE HTGZxSWT_SP and shall be displayed on the Graphics.
- .3 If any of the monitored heating valves have greater than 95% heating demand, increase the ACTIVE HTGZxSWT_SP by 1°C every 2 minutes until reaching the original outdoor reset schedule or until the maximum heating demand is less than 70%.

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City of Mississauga - Typical Points List & Standard Sequences of Operation

- .4 The monitored and control rooms on the associated radiation loop shall have an occupied, and unoccupied room temperature set-points. These points shall be adjustable from the graphics.
- .5 Occupied Mode:
 - .1 The EMCS shall modulate the heating valve to maintain occupied heating set point of 21.5°C (adjustable).
- .6 Unoccupied Mode:
 - .1 The EMCS shall modulate the heating valve to maintain an un-occupied room temperature setpoint of 18°C (adjustable).
- .7 The Occupied/Unoccupied heating schedule shall be according to the MSOSx for the related area of the building and as identified in the specified points list. The EMCS shall switch the rooms from un-occupied to occupied 1 hour prior to the start of the MSOSx).
- .5 Safeties:
 - .1 Heating valves shall fail normally open.
- .6 Alarm Points
 - .1 **Critical**
 - .1 Low Room Temp (RMT<14°C when OAT<5°C)
 - .2 **Environmental**
 - .1 Room temperature high/low limits
 - .3 **Maintenance**
 - .1 OAT< 5°C, heating valve at 100% demand for greater than 1 hour (adjustable)
 - .4 **Energy**
 - .1 OAT< 5°C, heating valve demand <20% for more than 1 hour (adjustable).
 - .5 The initial set up values for all alarms shall be established during the commissioning process.
- .7 Adjustable Points (to be displayed and accessed on system Setting Page)
 - Outdoor/Supply Water Reset Schedule Parameters
 - Alarm Settings (setpoints and time delay parameters as noted in part 2.16.6 Alarms)

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City of Mississauga - Typical Points List & Standard Sequences of Operation

2.16 DOMESTIC HOT WATER CONTROL

- .1 Anticipated Points.
 - DHWPMP-CMD - Domestic Hot Water Pump Start/Stop (1DO)
 - DHWPMP-ST - Domestic Hot Water Pump Status (1DI)
 - DHWVLV-CTL - Domestic Hot Water Valve Modulation (1AO)
 - DHWT-T - Domestic Hot Water Temp Temperature (1AI)
- .2 Start/Stop
 - .1 The domestic hot water recirculation pump (DHW PMP) shall be switched ON/OFF automatically by the EMCS on a time of day operating schedule.
- .3 Temperature Control
 - .1 Modulate the steam/hot water control valve to maintain a leaving water temperature (DHWT-T) from the heat exchanger of 120 F .(adjustable).
- .4 Safeties:
 - .1 Anti-scalding valves shall dump cold water into the system to prevent overheating of the DHW supply.
- .5 Alarm Points
 - .1 **Critical**
 - .1 N/A
 - .2 **Environmental**
 - .1 DHWST High/Low Limits
 - .3 **Maintenance**
 - .1 DHWST <DHWSTSP for more than 20 consecutive minutes (adjustable)
 - .4 **Energy**
 - .1 DHWPMP_ST on when DHWPMP_CMD is off
 - .5 The initial set up values for all alarms shall be established during the commissioning process.
- .6 Adjustable Points (to be displayed and accessed on system Setting Page)
 - DHWST_SP
 - Pump Operating Schedule
 - Alarm Parameters (Setpoints and time delay parameters as noted in part 2.16.5 Alarms)

Appendix B: City of Mississauga Forms and Templates

Appendix B City of Mississauga Forms and Templates

- B1 – CoM Points List Template**
- B2 – CoM Sample Points List**
- B3 – CoM Pre-Commissioning Checklist Form**
- B4 – CoM Project Acceptance Form**
- B5 – CoM Training Sign-Off Form**

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM DEFICIENCIES AND ACTION ITEMS

Project/Site: _____

Submitting for:

- ☐ Provisional Acceptance
- ☐ Final Acceptance
- ☐ Warranty Monitoring

The project has been reviewed against the prescribed acceptance criteria:

PROVISIONAL ACCEPTANCE

- | | |
|--------------------------|--|
| <input type="checkbox"/> | • System is completely installed, calibrated, tested and operational |
| <input type="checkbox"/> | • Preliminary deficiency items have been corrected |
| <input type="checkbox"/> | • Preliminary as-builts have been received |
| <input type="checkbox"/> | • Functional Testing Check List complete as specified (<u>Pre-Commissioning Checklist attached</u>) |
| <input type="checkbox"/> | • Commissioning has been scheduled with the owner and/or owner's agent |
| <input type="checkbox"/> | • Graphics Submitted are in accordance with the Graphical Template |
| <input type="checkbox"/> | • User Sign-In Levels have been Tested and are Operational with Proper Authorities and Restrictions |
| <input type="checkbox"/> | • Trend have been set up to specified intervals and Auto-upload to server is verified |
| <input type="checkbox"/> | • All Alarms have been tested and routing verified |

FINAL ACCEPTANCE

- | | |
|--------------------------|--|
| <input type="checkbox"/> | • Final commissioning is complete |
| <input type="checkbox"/> | • Attached deficiency list has been completed by the vendor |
| <input type="checkbox"/> | • Final documentation has been received |
| <input type="checkbox"/> | • Final as-builts updated and uploaded to graphics, hard copies received |
| <input type="checkbox"/> | • Software/Programming turned over to Owner |
| <input type="checkbox"/> | • Training is complete and Sign off Form Attached |

WARRANTY MONITORING

- ☐ • No identified deficiencies remain

This project stage is complete as indicated above.

Approver for the Vendor:

Date:

Approver for the Consultant:

Date:

Approver for the City of Mississauga:

Date:

City of Mississauga
EMCS ACCEPTANCE FORM

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM
DEFICIENCIES AND ACTION ITEMS

Project/Site:

ITEM	DESCRIPTION	ACTION BY	Date Completed	Contractor	Owner
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

City of Mississauga
EMCS ACCEPTANCE FORM

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM
DEFICIENCIES AND ACTION ITEMS

Project/Site:

Additional Project Comments/Notes:

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM

STAFF TRAINING

Project/Site:

STAFF TRAINING

<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>

- Final commissioning of the new EMCS is complete
- Facilities Staff can log on to the new EMCS
- Facilities Staff have the proper levels of EMCS access
- Facilities Staff have been trained to operate the new EMCS
- Facilities Staff questions have been addressed by the vendor

This project stage is complete as indicated above.

BAS Vendor:

Date:

Name

Signature

Date:

City of Mississauga Employee:

Name

Signature

Date:

City of Mississauga Employee:

Name

Signature

Appendix B1 - CoM Points List Template

Site
Site Address
Points Matrix

All existing power supplies, cabinets, relays, sensors, wiring to be replaced unless otherwise noted. Conduits may be reused in whole or in part. Unused conduit to be removed. Applies to all existing points unless otherwise noted.									
The Site ID for ##### is ####. All points are to use this Site ID as a prefix (e.g.#### RTU/FAN_CMD).									
System Identifier		Location		Power Panel		Sequence		Serving	
Existing Point Name		Tag		Point Description		Type		Units in Display	
				</					

Appendix B3 - CoM Sample Points List

Port Credit Arena
40 Stavebank Rd, Mississauga ON
Points Matrix

All existing power supplies, cabinets, relays, sensors, wiring to be replaced unless otherwise noted. Conduits may be reused in whole or in part. Unused conduit to be removed. Applies to all existing points unless otherwise noted.

The Site ID for Port Credit Arena is PCA1. All points are to use this Site ID as a prefix (e.g. PCA1_RTU1FAN_CMD).

System Identifier HHAI	Location		Power Panel		Sequence	Serving	
	Roof (ADDITION) Tag	Existing Point Name	Point Description	Type		Rink B Change Rooms Units in Display	Comments
New Point	RTU1BACNET_COM		RTU-1 BaeNet Communication (MS/TP)	COM	Online/Offline	Integrate with existing Delta DDC Controller via BACNet MS/TP	
New Point	RTU1FAN_CMD		RTU-1 Fan Command	VP	On/Off	Control point via BACNet	
New Point	RTU1MODE_CMD		RTU-1 Control Mode	VP	Unoccupied/Ventilation	Control point via BACNet	
New Point	RTU1SF_STS		RTU-1 Supply Fan Status	VP	On/Off	Point read via BACNet	
New Point	RTU1EF_STS		RTU-1 Exhaust Fan Status	VP	On/Off	Point read via BACNet	
New Point	RTU1ERW_STS		RTU-1 ERV Wheel Status	VP	On/Off	Point read via BACNet	
New Point	RTU1ERW_SPD		RTU-1 ERV Wheel Speed	VP	%	Point read via BACNet	
New Point	RTU1OAT_T		RTU-1 Outdoor Air Temperature	VP	°C	Point read via BACNet (if available)	
New Point	RTU1OAH_HUM		RTU-1 Outdoor Air Relative Humidity	VP	% RH	Point read via BACNet (if available)	
New Point	RTU1SAT_T		RTU-1 Supply Air Temperature	VP	°C	Point read via BACNet	
New Point	RTU1RAT_T		RTU-1 Return Air Temperature	VP	°C	Point read via BACNet	
New Point	RTU1ERWDISCHT_T		RTU-1 ERW Discharge Air Temperature	VP	°C	Point read via BACNet (if available)	
New Point	RTU1EAT_T		RTU-1 Exhaust Air Temperature	VP	°C	Point read via BACNet	
New Point	RTU1BUR_STS		RTU-1 Burner Status	VP	%	Point read via BACNet	
New Point	RTU1ICLG1_STS		RTU-1 Cooling Stage 1 Status	VP	On/Off	Point read via BACNet - May not be required if Cooling is not enabled	
New Point	RTU1ICLG2_STS		RTU-1 Cooling Stage 2 Status	VP	On/Off	Point read via BACNet - May not be required if Cooling is not enabled	
New Point	RTU1SAT_SPT_WINT		RTU-1 Winter Supply Air Setpoint	VP	°C	Virtual Point	
New Point	RTU1SAT_SPT_HTG		RTU-1 Heating Supply Air Setpoint	VP	°C	Virtual Point	
New Point	RTU1SAT_SPT_SUMM		RTU-1 Summer Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled	
New Point	RTU1SAT_SPT_CLG		RTU-1 Cooling Supply Air Setpoint	VP	°C	Virtual Point - May not be required if Cooling is not enabled	
New Point	RTU1ECON_SPT_ENTH		RTU-1 Economizer Enthalpy Setpoint	VP	BTU/lb	Virtual Point - May not be required if Cooling is not enabled	
New Point	RTU1ROOM_SPT		RTU-1 Space Setpoint	VP	°C	Virtual Point	
New Point	RTU1IRMT134_T		RTU-1 Room 134 Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 134	
New Point	RTU1IRMT136_T		RTU-1 Room 136 Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 136	
New Point	RTU1IRMT138_T		RTU-1 Room 138 Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 138	
New Point	RTU1IRMT142_T		RTU-1 Room 142 Space Temperature	Ai	°C	New Flat Plate Sensor Installed in Room 142	
New Point	RTU1IRMT134_OCC		RTU-1 Room 134 Occupancy	Di	Occupied/Unoccupied	Utilize Existing Occupancy Sensor Installed in Room 134	
New Point	RTU1IRMT136_OCC		RTU-1 Room 136 Occupancy	Di	Occupied/Unoccupied	Utilize Existing Occupancy Sensor Installed in Room 136	
New Point	RTU1IRMT134_OCC		RTU-1 Room 138 Occupancy	Di	Occupied/Unoccupied	Utilize Existing Occupancy Sensor Installed in Room 138	
New Point	RTU1IRMT142_OCC		RTU-1 Room 142 Occupancy	Di	Occupied/Unoccupied	Utilize Existing Occupancy Sensor Installed in Room 142	

System Identifier Exhaust Fans	Location Various		Power Panel		Sequence	Serving Washrooms/Changerooms
	Existing Point Name	Tag	Point Description			
New Point		WREF1_CMD	Washroom Exhaust Fan 1 Command		Do	On/Off
New Point		WREF2_CMD	Washroom Exhaust Fan 2 Command		Do	On/Off
New Point		WREF1_STS	Exhaust Fan 1 Status		Di	On/Off
New Point		WREF2_STS	Exhaust Fan 2 Status		Di	On/Off
New Point		CR117_OCC	Changeroom 117 Occupancy		Di	On/Off
New Point		CR117EF_STS	Changeroom 117 Exhaust Fan Status		Di	On/Off
New Point		CR118_OCC	Changeroom 118 Occupancy		Di	On/Off
New Point		CR118EF_STS	Changeroom 118 Exhaust Fan Status		Di	On/Off

Pre-Commissioning Check List

The following Check List will be prepared by the controls Vendor and Submitted to Ameresco Prior to scheduling of Commissioning

Facility Name _____
Municipal Address _____
IP Address _____
Company _____

Panel No: _____	Location: _____	Power Supplied From: _____
-----------------	-----------------	----------------------------

Auto Restoration on Loss of Power _____
Wires Labelled _____
Panel Schedule Enclosed _____
Existing Redundant Controls Removed _____

Point No	Name Descriptor	Description	Type	Device	Fail Mode	Verified By	Comments

Additional Comments/Site Notes:

Control Technician _____
Print Name _____
Date _____

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM
DEFICIENCIES AND ACTION ITEMS

Project/Site:

Submitting for:

- ☐ Provisional Acceptance
☐ Final Acceptance
☐ Warranty Monitoring

The project has been reviewed against the prescribed acceptance criteria:

PROVISIONAL ACCEPTANCE

- | | |
|--------------------------|--|
| <input type="checkbox"/> | • System is completely installed, calibrated, tested and operational |
| <input type="checkbox"/> | • Preliminary deficiency items have been corrected |
| <input type="checkbox"/> | • Preliminary as-builts have been received |
| <input type="checkbox"/> | • Functional Testing Check List complete as specified (<u>Pre-Commissioning Checklist attached</u>) |
| <input type="checkbox"/> | • Commissioning has been scheduled with the owner and/or owner's agent |
| <input type="checkbox"/> | • Graphics Submitted are in accordance with the Graphical Template |
| <input type="checkbox"/> | • User Sign-In Levels have been Tested and are Operational with Proper Authorities and Restrictions |
| <input type="checkbox"/> | • Trend have been set up to specified intervals and Auto-upload to server is verified |
| <input type="checkbox"/> | • All Alarms have been tested and routing verified |

FINAL ACCEPTANCE

- | | |
|--------------------------|--|
| <input type="checkbox"/> | • Final commissioning is complete |
| <input type="checkbox"/> | • Attached deficiency list has been completed by the vendor |
| <input type="checkbox"/> | • Final documentation has been received |
| <input type="checkbox"/> | • Final as-builts updated and uploaded to graphics, hard copies received |
| <input type="checkbox"/> | • Software/Programming turned over to Owner |
| <input type="checkbox"/> | • Training is complete and Sign off Form Attached |

WARRANTY MONITORING

- ☐ • No identified deficiencies remain

This project stage is complete as indicated above.

Approver for the Vendor:

Date:

Approver for the Consultant:

Date:

Approver for the City of Mississauga:

Date:

City of Mississauga
EMCS ACCEPTANCE FORM

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM
DEFICIENCIES AND ACTION ITEMS

Project/Site:

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City of Mississauga
EMCS ACCEPTANCE FORM

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM
DEFICIENCIES AND ACTION ITEMS

Project/Site:

Additional Project Comments/Notes:

EMCS PROJECT ACCEPTANCE SIGN-OFF FORM

STAFF TRAINING

Project/Site:

STAFF TRAINING

<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>
<input type="checkbox"/>

- Final commissioning of the new EMCS is complete
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- Facilities Staff questions have been addressed by the vendor

This project stage is complete as indicated above.

BAS Vendor:

Date:

Name

Signature

Date:

City of Mississauga Employee:

Date:

Name

Signature

Date:

City of Mississauga Employee:

Date:

Name

Signature

Date:

EMCS: GENERAL SCOPE OF WORK

Part 1	General	2
1.1	REQUIREMENTS	2
1.2	GENERAL OBJECTIVES	2
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1.4	SEPARATE PRICE #1	Error! Bookmark not defined.
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EMCS: GENERAL SCOPE OF WORK

Part 1 General

1.1 REQUIREMENTS

- 1.1.1 Conform to the General requirements of Divisions 00, 01, 22, 23 and 24
- 1.1.2 Conform to the requirements of the “Master Specifications for Energy Management Control Systems” Latest Revision including requirements of the following Sections:
 - 1.1.2.1 Section 25 01 11 – EMCS: Start-up, Verification and Commissioning
 - 1.1.2.2 Section 25 01 12 – EMCS: Training
 - 1.1.2.3 Section 25 05 01 – EMCS: General Requirements
 - 1.1.2.4 Section 25 05 02 – EMCS: Submittals and Review Process
 - 1.1.2.5 Section 25 05 03 – EMCS: Project Record Documents
 - 1.1.2.6 Section 25 05 54 – EMCS: Identification
 - 1.1.2.7 Section 25 08 20 – EMCS: Warranty and Maintenance
 - 1.1.2.8 Section 25 10 01 – EMCS: Local Area Network (LAN)
 - 1.1.2.9 Section 25 30 01 – EMCS: Building Controllers, Family of Controllers
 - 1.1.2.10 Section 25 03 02 – EMCS Field Control Devices
 - 1.1.2.11 Section 25 90 01 – EMCS Site Requirements, Applications and System Sequences of Operation
 - 1.1.2.12 Appendix A – City of Mississauga Standards and Guidelines
 - 1.1.2.13 Appendix B – City of Mississauga Forms and Templates

1.2 GENERAL OBJECTIVES

- 1.2.1 This project is [PROJECT NAME/DESCRIPTION] for the City of Mississauga Energy Management Control Systems (EMCS) involving the [replacement of existing controls],[installation of a new control system] including work at site and the modification of Owner’s EMCS Enterprise Server Software (ESS) for the City of Mississauga.
- 1.2.2 The scope of work for this contract shall include [the complete removal of existing electrical/pneumatic/digital controls (including abandoned and redundant controls) and] the installation of new direct digital controls including Niagara JACE 8000 Series Supervisory Controller(s), all remote programable digital controllers (RPDC), Terminal Equipment Controllers (TEC) and connection to OEMASC for a complete and functional control system. The number of field controllers shall be of sufficient number to accommodate the points identified in the points list and specified here within. The new control system shall be in accordance with the City of Mississauga “Master Specifications for Energy Management Control Systems (EMCS)” operating on the City of Mississauga Niagara 4 platform.
- 1.2.3 This contract requires the full development of NEW site-specific customized graphics in accordance with the City of Mississauga Graphical Standards. The contractor shall utilize existing graphical workstation(s) as a guideline for the starting point of development of the new graphics and shall work closely with the Owner and Consultant to create the site specific graphics (including possible enhancements to the existing Graphical Standard).
- 1.2.4 The EMCS contractor shall meet with the Owner and Consultant within 2 weeks of the Project Start-Up meeting to specifically discuss the requirements for new system graphics and associated plan of execution.

EMCS: GENERAL SCOPE OF WORK

- 1.2.5 The EMCS contractor shall anticipate a reiterative process whereby the graphics will be submitted multiple times for review and comment, followed by revision(s) until both the Owner and Consultant are satisfied with the end result (and graphics approval is granted). **NO CONTROL INSTALLATION WORK CAN BEGIN ON SITE UNTIL THE GRAPHICS ARE SUBMITTED AND APPROVED.**
- 1.2.6 [Remove existing, supply and install all new cabinet enclosures, new controllers, power supplies, control wiring, hardware and end devices for a complete and total system as indicated. The contractor shall NOT re-use existing cabinets, controllers, wiring, relays, sensors, or other end devices unless otherwise noted. Conduits may be re-used to run new wiring].
- 1.2.7 Provide all new programming to achieve energy efficiency in accordance with the specified sequence of operation and at the direction of the consultant.
- 1.2.8 Perform all Pre-Commissioning activities including Functional and Performance Testing, Completion of Pre-Commissioning Checklists, Submission of Provisional Acceptance Forms.
- 1.2.9 Upon submission and acceptance of the Provisional Acceptance Forms by the Owner and Consultant, arrange for a Commissioning date through the Prime Contractor. EMCS contractor shall guide and assist Commission Agent to inspect and verify a second round of functional and performance testing to achieve optimized performance of the building and building systems.
- 1.2.10 Complete training, submit documentation and correct all deficiencies in a timely manner prior to submission of Final Acceptance Forms

1.3 SPECIFIC SCOPE OF WORK – [SITE NAME]

Specification Note: This section is where the details of the site-specific project should be described by the Consultant/Design Engineer. The following is a typical example:

- 1.3.1 The scope of work for [SITE NAME] shall include the complete disconnect and removal of existing abandoned and redundant electrical/pneumatic/digital controls, including all control cabinets, power supplies, wiring, relays, sensors and other end devices. Contractor shall walk through the job site with Owner/Consultant at the start of the job to confirm and review total extent of removals.
- 1.3.2 Supply and install all new control cabinets, power supplies, relays, actuators, sensors, thermostats, wiring, etc. as specified and as necessary to achieve the specified sequence of operation associated with the replacement of existing and addition of new control points. Refer to points list and sequences of operation in Appendix [A].

Specification Note: Consultant/Design Engineer to make use of the CoM materials as outlined in the Design Guideline and Master Specifications to generate a points lists and associated sequence of operation to be included in the project specifications. All points to be named using the CoM point naming convention. Sequences and points list shall be submitted to, and approved by, the CoM before tender.

 - 1.3.2.1 The contractor may re-use existing conduits where possible. All wiring, sensors, relays, end devices, etc. as indicated in points list to be replaced shall be removed and replaced with new.
 - 1.3.2.2 Provide all programming as outlined in the Sequences of Operation detailed in Appendix [A] including all new customized site-specific graphics in accordance with the City of Mississauga Master Specifications for Energy Management Control systems EMCS.

EMCS: GENERAL SCOPE OF WORK

- 1.3.2.3 All graphics, EMCS control programming, trend data, security settings, access level priorities, etc. shall be uploaded by the EMCS contractor and stored on the EMCS Server prior to the start of commissioning and again upon completion of deficiency clean-up and submission of as-built. The EMCS contractor shall set-up automatic back-up of the site databased and programming to the server at the direction of CoM Energy Management Specialist.
- 1.3.2.4 The dedicated EMCS server shall be the primary global interface.
- 1.3.2.5 The SRPDC shall have an Open Nics statement and be licensed to the owner and shall have a minimum of 20% spare capacity for additional points/controllers associated with this installation.
- 1.3.3 Provide new “as-built” drawings including all new/modified points, communication BUS and location of field panels, terminal equipment controllers, and associated power supplies, updated panel termination diagrams and revised sequence of operation.

1.4 SHOP DRAWINGS AND PRODUCT DATA

- 1.4.1 Submit shop drawings and product data in accordance with Section 01 33 00 of these specifications and the requirements of City of London Master Specifications for EMCS Upgrades.

1.5 ELECTRICAL WIRING

- 1.5.1 Submit shop drawings and product data in accordance with Section 01 33 00 of these specifications.
- 1.5.2 All wiring shall comply with local and national electrical codes and the requirements of Divisions 22, 23 and 24.
- 1.5.3 All control and sensor wiring shall be colour coded in compliance with designated colour scheme by vendor.
- 1.5.4 All wiring shall be plenum rated Beldon or equivalent, #18, #20 or #22-gauge, non-shielded wiring when in conduit, shielded where exposed. Lengths for specific gauge and applications shall comply with the control’s manufacturer’s guidelines. Exposed wiring in service areas (Mechanical/Electrical) shall be in EMT conduit, plenum rated cable above ceilings. Any exposed wiring in corridors, classrooms, etc. (finished areas) shall be in wire mold.
- 1.5.5 Size 24 VAC wiring according to length. Refer to manufacturer’s voltage drop table and size wire to achieve a minimum of 22 VAC at the control being powered.
- 1.5.6 The use of wire-nuts for connections on communication bus is prohibited. Use “Scotchlok” 3M terminals or other similar terminal block type product.
- 1.5.7 All new controls shall have an independent power supply with dedicated breaker. This contractor shall be responsible for finding available power and labelling panel(s) for new control circuits.
- 1.5.8 **120VAC to 24 V power control transformers shall be supplied and installed in a rated electrical enclosure and wired to control panel(s). Control cabinets shall have 24Vdc only and a dedicated terminal strip as per the Master Specifications Rev 1.**

EMCS: GENERAL SCOPE OF WORK

Part 2 Products

2.1 GENERAL

- 2.1.1 The control system shall be comprised of complete stand-alone controllers, sensor, relays, power and control wiring where required, and other required accessories for the complete control of the specified renovations under this Contract. Control system shall be capable of accomplishing the sequence of operation as specified herein.
- 2.1.2 New controls shall be in accordance with the City of Mississauga “Master Specifications for Energy Management Control Systems” latest revision. Pre-Qualified bidders shall only submit for the Family of Controllers as listed in Section 25 30 01 and as follows:

Company Name	Branch Location	Contact Person	EMCS Family of Products
Facio Corporation	145 West Beaver Creek Rd, Richmond Hill, ON L4B 1C6	Gary MacMillan gmacmillan@facio.ca	Honeywell Spyder BacNet IP series (programmable via Niagara Workbench) and Ciper series controller. Distech Eclipse BacNet IP series controllers
Automated Controls and Energy Solutions Group Inc.	5285 Solar Dr Unit 103, Mississauga, ON L4W 5B8	Murat Kinaci estimates@acesolutionsgroup.ca	Honeywell Spyder BacNet IP series (programmable via Niagara Workbench) and Ciper series controller
Airon HVAC and Control Ltd.	5150 Fairview St, Burlington, ON L7L 6B7	Tanya Meade <i>tanyam@airongroup.ca</i>	Honeywell Spyder BacNet IP series (programmable via Niagara Workbench) and Ciper series controller
Ainsworth Inc.	131 Bermondsey Rd, North York, ON M4A 1X4	Julian Rogochevsky <i>Julian.Rogochevsky@ainsworth.com</i>	Schneider Smart X BacNet IP series, with Niagara module (programmable via Niagara Workbench)
Accu-Temp Systems Inc.	226 St Leger St, Kitchener, ON N2H 4M5	Scott Ward <i>Scottw@accutempsystems.com</i>	Honeywell Spyder BacNet IP series (programmable

EMCS: GENERAL SCOPE OF WORK

			via Niagara Workbench) and Ciper series controller
Modern Niagara Toronto Inc	8125 Hwy 50 Vaughan, Ontario L4L 1A5	Sam Boyajian <i>Sboyajian@modernniagara.com</i>	Distech – Eclipse – Bacnet IP series controllers

- 2.1.3 All products must be CSA approved and BACnet certified.
- 2.1.4 Where the number of connected field controllers requires multiple SRPDC (Jace) panels for proper operation, contractor shall supply and connect to the EMCS Network including any necessary switches/routers.
- 2.1.5 All JACE panels shall come with Open NiCS statements.

Part 3 EXECUTION

3.1 GENERAL

- 3.1.1 The complete control system installation shall be the responsibility of pre-approved Energy Management Control System (EMCS) Contractors only (see 2.1.2). Unsolicited bids/proposals from other vendors will not be considered.
- 3.1.2 The wiring of the controls system shall be done in accordance with all code authorities having jurisdiction.
- 3.1.3 Exposed wiring shall be in EMT conduit, plenum rated (FT6) shall be acceptable above ceiling system, and wire mold shall be used in finished areas. Ethernet Communication cabling for EMCS Sub-Networks shall be in conduits throughout.
- 3.1.4 All conduits shall be extended to with 24-36 in of equipment/end devices before converting to flexible (liquid tight) conduit. Liquid tight/flexible conduit shall not be run for extended lengths, or from sensor to sensor.
- 3.1.5 Control relays shall be in accordance with Master Specifications and mounted in a dedicated electrical box (unless otherwise noted). RIB shall NOT be accepted.
- 3.1.6 Safety controls shall have priority with respect to control of equipment. Coordinate installation of the system to ensure that interfacing and connection of controls to equipment will not bypass or interfere with freeze stats, heat detector or other safety controls.

3.2 LOCATION OF CONTROL SYSTEM EQUIPMENT

- 3.2.1 New controllers, actuators, etc., to be mounted in the associated mechanical/electrical room within a NEMA rated enclosure, in accordance to Section 25 05 01 of the Master Specifications for EMCS Installations.
- 3.2.2 All wiring shall be brought to a dedicated Terminal Strip within the control cabinet and terminated. Wiring shall then be run from each associated termination point on the Terminal strip to the corresponding termination point on the controller Termination Board. Direct wiring or sensors/devices to the controller shall not be permitted.

EMCS: GENERAL SCOPE OF WORK

- 3.2.3 The location of Terminal Equipment Controllers (TEC) shall be dictated by the placement/location of terminal equipment to be controlled (i.e. Heat-Pump, Unit Ventilator, perimeter radiation etc.). Only VAV Boxes shall have direct mounted control equipment, all other equipment shall have controller mounted within a rate enclosure (see 3.2.4 below).
- 3.2.4 Except where otherwise noted, TEC shall be mounted in a NEMA 1 enclosure located on the building structure within five (5) feet of terminal equipment being controlled (duct work & piping are not building structure). Wiring shall be run in liquid Tight flexible conduit between the Controller enclosure and Terminal equipment to be controlled, neatly installed and secured to structure (running as close as possible to point of final termination). EMCS Contractor shall place a lamacoid plate or P-Touch label on the ceiling tile support system directly below each terminal device indicating the controller name (i.e. VAV1).
- 3.2.5 Controllers may be mounted inside of the equipment where dedicated control space is possible. If controller cannot be mounted inside equipment, it should be mounted in an enclosure located in the ceiling space above. In some instances, it may be necessary (with approval of Owner) to install within the occupied space in a lockable, NEMA enclosure, mounted at serviceable height (4 ft) on wall.

3.3 SEQUENCE OF OPERATIONS

- 3.3.1 Refer to specified Sequences of Operation in Appendix A.
- 3.3.2 Sequences are somewhat generic in nature. Contractor shall work with Owner and/or consultant to modify sequences as necessary to achieve optimal system performance. This shall be done at no additional cost to the project.

3.4 WARRANTIES

- 3.4.1 Control system component manufacturers shall guarantee a minimum one (1) year for all control devices and five (5) years of software updates for the SRPDC. All warranties shall be given to the Owner.
- 3.4.2 Note that all warranties to commence from time of final acceptance. Contractor to utilize the EMCS Project Acceptance Forms (See Appendix B).

END OF SECTION 25 01 00

Spec Note: Consultant to include points list, Sequence of operations, and applicable CoM Forms (EMCS Acceptance, Training sign-off, Pre-commissioning Checklist) with the project specifications. Refer to CoM EMCS Design Guidelines.