1 General

1.1 REFERENCES

.1 Division 00 and Division 01 apply to and are a part of each Mechanical Division:

.1 Division 21 – Fire Suppression;

.2 Division 22 – Plumbing;

.3 Division 23 – Heating, Ventilating, and Air Conditioning;

.4 Division 25 - Integrated Automation.

1.2 APPLICATION

.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.

1.3 SUBMITTALS

.1 Submit shop drawings/product data sheets for:

.1 pressure gauges and thermometers;

.2 electric motors (submit with equipment they are associated with).

.2 Submit weight loads for selected equipment (upon request).

.3 Submit copy of architectural reflected ceiling plan drawings and elevation drawings to indicate proposed access door locations.

.4 Submit a list of equipment identification nameplates indicating proposed wording and sizes.

.5 Submit a list of pipe and duct identification colour coding and wording.

.6 Submit a proposed valve tag chart and a list of proposed valve tag numbering and identification wording.

.7 Submit drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.

.8 Submit any other submittals specified in this Section or other Sections of Mechanical Divisions.

2 Products

2.1 PIPE SLEEVES

.1 Galvanized Sheet Steel – Minimum #16 gauge galvanized steel with an integral flange at one end to secure sleeve to formwork construction.

.2 Polyethylene – Factory fabricated, flanged, high density polyethylene sleeves with reinforced nail bosses.

.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.

.4 Galvanized Steel or Cast Iron Pipe – Schedule 40 mild galvanized steel, or Class 4000 cast iron.

2.2 FIRESTOPPING AND SMOKE SEAL MATERIALS

.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.

2.3 WATERPROOFING SEAL MATERIALS

.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.

.2 Acceptable products are:

- .1 Thunderline Corp. (Power Plant Supply Co.) "LINK SEAL" Model S-316;
- .2 The Metraflex Co. "MetraSeal" type ES.

2.4 PIPE ESCUTCHEON PLATES

.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.

2.5 PIPING HANGERS AND SUPPORTS

.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:

- .1 unless otherwise specified, ferrous hanger and support products are to be electro-galvanized;
- .2 hangers and supports for insulated piping are to be sized to fit around insulation and insulation jacket.

.2 Hangers and supports for horizontal suspended piping as follows:

- .1 adjustable steel clevis hanger – MSS Type 1;
- .2 adjustable swivel ring band hanger – MSS Type 10;

.3 Supports for horizontal pipe on vertical surfaces as follows:

- .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
- .2 heavy-duty steel pipe clip – MSS Type 26;
- .3 single steel pipe hook – Myatt Fig. 156;
- .4 epoxy coated steel pipe stays are not permitted.

.4 Floor supports for vertical risers as follows:

- .1 copper tubing riser clamp – MSS Type 8;
- .2 heavy-duty steel riser clamp – MSS Type 8.

.5 Supports for vertical piping on vertical surfaces as follows:

- .1 steel offset pipe clamp – Anvil Fig. 103 or Myatt Fig. 170;
- .2 heavy-duty steel pipe bracket or soil pipe bracket – MSS Type 26;
- .3 extension split pipe clamp – MSS Type 12;
- .4 epoxy coated steel pipe stays are not permitted.

.6 For horizontal pipe on racks, Unistrut or equal galvanized steel pipe racks with pipe securing hardware as follows:

- .1 standard galvanized steel U-bolts/clamps supplied by rack manufacturer;

.7 Special hangers and supports for various applications as follows:

.1 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 for sections of piping connected to vibration isolated equipment – hangers and supports as specified above but complete with MSS Type 48 spring cushions;

.3 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;

.4 for plastic piping – generally as specified above but in accordance with pipe manufacturer's recommendations;

.5 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;

.6 for bare horizontal copper piping – generally as above but factory vinyl coated to prevent direct copper/steel contact;

.7 for bare copper vertical piping – corrosion resistant ferrous clamps with flexible rubber gasket type material (not tape) to isolate pipe from clamp;

.8 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.

.8 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.

.9 Acceptable manufacturers are:

.1 E. Myatt & Co. Inc.;

.2 Anvil International Inc.;

.3 Empire Industries Inc.;

.4 Hunt Manufacturing Ltd.;

.5 Unistrut Canada Ltd.;

.6 Nibco Inc. "Tolco";

.7 Taylor Pipe Supports.

2.6 ACCESS DOORS

.1 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 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.

.3 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.

.4 Lay-in type tiles, properly marked, may serve as access panels. Coordinate marking of ceiling tiles with 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.

.5 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.

.6 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.

.7 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.

.8 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.

.9 Acceptable manufacturers include Le Hage, SMS, Pedlar and Acudor.

2.7 PRESSURE GAUGES AND THERMOMETERS

.1 Pressure gauges as follows:

.1 adjustable, glycerine filled, 100 mm or 115 mm (4" or 4-½") diameter and each accurate to within 1% of scale range;

.2 type 304 stainless steel case with relief valve and polished stainless steel bayonet;

.3 stainless steel rotary movement with stainless steel bushings and socket;

.4 clear acrylic window;

.5 dual scale white dial with a scale range such that working pressure of system is at approximate mid-point of scale;

.6 black pointer.

.2 Pressure gauge accessories and additional requirements as follows:

.1 a bronze ball type shut-off valve is to be provided in the piping to each pressure gauge;

.2 each pressure gauge for piping and equipment with normal everyday flow is to be equipped with a brass pressure snubber;

.3 each pressure gauge for steam piping or steam equipment is to be equipped with a steel coil syphon;

.4 pressure gauges in fire protection piping must be ULC listed and labelled;

.3 Thermometers as follows:

.1 round, 125 mm (5") diameter, adjustable (90°) angle bimetal dial type thermometers, each accurate to within 1% of full scale;

.2 hermetically sealed stainless steel case with stainless steel ring;

.3 dampened bimetal coil;

.4 calibration adjustment screw;

.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;

.6 black aluminum pointer;

.7 double strength glass window;

.8 12 mm (½") NPT connection with 6.4 mm (¼") diameter stainless steel stem;

.9 suitable thermowell.

.4 Acceptable manufacturers are:

.1 H.O. Trerice Co.;

.2 Weiss Instruments;

.3 Ashcroft.

2.8 EQUIPMENT BELT DRIVES

.1 ANSI/RMA Standard V-belt type rated at minimum 1.5 times motor nameplate rating, and in accordance with following requirements:

.1 belts are to be reinforced cord and rubber, and multiple belts are to be matched sets;

.2 sheaves are to be cast iron or steel, secured to shafts with removable keys unless otherwise specified, standard adjustable pitch (± 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;

.3 motor slide rail adjustment plates are to allow for centre line adjustment.

.2 Supply a spare belt set (tagged and identified) for each belt drive and hand to Owner upon Substantial Performance of the Work.

2.9 EQUIPMENT DRIVE GUARDS AND ACCESSORIES

.1 For V-belt drives – removable, 4-sided, fully enclosed, galvanized sheet steel guards to OHSA 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 (1-½") diameter tachometer openings at each shaft location.

.2 For flexible couplings – removable "U" shaped galvanized steel guards to OHSA Standards with a 2.3 mm (3/32") thick frame and expanded mesh face.

.3 For unprotected fan inlets and outlets – unless otherwise specified, removable 20 mm (¾") galvanized steel wire mesh with galvanized steel frames, all to OHSA Standards.

2.10 ELECTRIC MOTORS

.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 Vertically mounted and submersible motors are to be purposely designed for mounting in this attitude.

.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.

.4 Unless otherwise specified, 1-phase motors smaller than ½ HP are to be 115 volt, 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.

.5 Explosion-proof 1-phase motors are to be totally enclosed, fan cooled, 115 volt 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.

.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.

.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.

.8 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.

.9 Acceptable manufacturers are:

.1 TECO-Westinghouse Motors (Canada) Inc.;

.2 Canadian General Electric;

.3 Baldor Electric Co.;

.4 U.S. Electrical Motors;

.5 Weg Electric Corp.;

.6 Marathon Electric;

.7 Toshiba Corp.;

.8 Leeson Canada.

2.11 SPRINKLER PROOFING

.1 Provide drip shields for protection of surface mounted equipment enclosures from water spray and dripping of liquids. Features of shields include:

.1 factory constructed by respective equipment manufacturers;

.2 constructed from non-combustible materials (sheet steel);

.3 enamel painted to match equipment;

.4 surfaces and edges filled/sanded smooth prior to painting;

.5 supported from equipment with structural steel rods/metal framing or other method approved by Consultant;

.6 structural support finish painted to match shield.

.2 Include with equipment shop drawings, detailed dimensions of drip shields and methods of supporting.

.3 Equipment with top cable/conduit entries to include additional sealing of entries with gasketting and/or waterproof sealant to prevent water from entering enclosure.

.4 Design ventilation louvers such that live components are not exposed to water spray and dripping liquids.

.5 Above requirements are additional minimum "sprinkler proof" standards for equipment specified as NEMA 1, 2 or 12.

.6 Obtain CSA approval where required by local governing authorities.

2.12 MECHANICAL WORK IDENTIFICATION MATERIALS

.1 Confirm with the Owner if an existing mechanical work identification system is in place and, if so, match accordingly.

.2 If an existing mechanical work identification system is not in place, the following is to be used:

.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 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

.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.

.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
storm drainage	green	STORM
sanitary drainage	green	SAN.
plumbing vent	green	SAN. VENT
fire protection sprinklers	red	F.P. SPRINKLER

PIPE SERVICE	IDENTIFICATION COLOUR	LEGEND
natural gas	to Code	to Code, c/w pressure
natural gas vent	to Code	to Code
low pressure steam	yellow	….kPa STEAM
low pressure condensate	yellow	L.P. CONDENSATE
pumped condensate	yellow	PUMPED CONDENSATE
refrigerant suction	yellow	REFRIG. SUCTION
refrigerant liquid	yellow	REFRIG. LIQUID
refrigerant hot gas	yellow	REFRIG. HOT GAS

.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

.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.

2.13 FLEXIBLE CONNECTORS

.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. Acceptable manufacturers are:

.1 Hyspan Precision Products Inc.;

.2 Senior Flexonics Ltd.;

.3 The Metraflex Co.

3 Execution

3.1 GENERAL PIPING AND DUCTWORK INSTALLATION REQUIREMENTS

.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.

.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 Architectural drawings and room finish schedules to determine finished, partially finished, and unfinished areas. Walls which are painted are considered finished.

.3 Install pipes and ducts parallel to building lines and to each other.

.4 Neatly group and arrange exposed work.

.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.

.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.

.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.

.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.

.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.

.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.

.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.

.12 Provide continuous galvanized sheet metal drip pan under drain, water and water solution piping extending through rooms with electrical equipment such as electrical, elevator equipment and transformer rooms, and other spaces provided primarily for the installation of electrical equipment. Drip pans are to be complete with a drain pipe connection and drain piping is to be extended to closest drain.

.13 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.

.14 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.

.15 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.

.16 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

.1 Do not make pipe joints in walls or slabs.

.2 Ream piping ends prior to making joints.

.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.

.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.

.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.

.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.

.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.

.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.

.9 Install mechanical joint fittings and couplings in accordance with manufacturer's instructions.

.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.

.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.

.12 Solvent weld PVC piping in 2 parts, primer stage and cementing stage, in accordance with manufacturer's recommendations, ASTM D2855, and CSA requirements.

.13 Install PVC piping with gasketed joints in accordance with manufacturer's current published specifications, instructions and recommendations, and CSA requirements.

3.3 INSTALLATION OF PIPE SLEEVES

.1 Where pipes pass through concrete and/or masonry surfaces provide pipe sleeves as follows:

.1 in poured concrete slabs – unless otherwise specified, minimum 16 gauge flanged galvanized steel or, where permitted by governing authorities, factory fabricated plastic sleeves;

.2 in concrete or masonry walls – Schedule 40 galvanized steel pipe or Class 4000 cast iron pipe.

.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:

.1 in mechanical room floor slabs, except where on grade;

.2 in slabs over mechanical, fan, electrical and telephone equipment rooms or closets;

.3 in floors equipped with waterproof membranes;

.4 in roof slab;

.5 in waterproof walls.

.3 Size sleeves, unless otherwise specified, to leave 12 mm (½") clearance around pipes, or where pipe is insulated, a 12 mm (½") clearance around pipe insulation.

.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:

.1 pack sleeves in interior construction with mineral wool and seal both ends of sleeves with non-hardening silicone base caulking compound;

.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 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.

.5 Where sleeves are required in masonry work, accurately locate and mark sleeve location, and hand sleeves to mason for installation.

.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.

.7 "Gang" type sleeving will not be permitted.

.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.

3.4 INSTALLATION OF WATERPROOF MECHANICAL SEALS

.1 Provide watertight link type mechanical seals in exterior wall openings.

.2 Assemble and install each mechanical seal in accordance with manufacturer's instructions.

.3 After installation, periodically check each mechanical seal installation for leakage and, if necessary, tighten link seal bolts until seal is completely watertight.

3.5 DUCT OPENINGS

.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.

.2 Size openings for fire dampers to 600 mm (24") high to suit damper arrangement with folding blade out of air stream.

.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.

3.6 SLEEVE AND FORMED OPENING LOCATION DRAWINGS

.1 Prepare and submit for review, drawings indicating size and location of required sleeves, recesses and formed openings in poured or precast concrete work.

.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 Begin to prepare such drawings immediately upon notification of acceptance of bid and award of Contract.

3.7 INSTALLATION OF PIPE ESCUTCHEON PLATES

.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.

.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.

3.8 INSTALLATION OF FASTENING AND SECURING HARDWARE

.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.

.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 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.

.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.

.5 Do not attach fasteners to steel deck without written consent from Consultant.

3.9 INSTALLATION OF PIPE HANGERS AND SUPPORTS

.1 Provide required pipe hangers and supports.

.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 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.

.4 Support requirements for underground piping are as follows:

.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;

.2 support underground service piping penetrating building exterior walls or foundations to prevent pipe damage if minor building settlement occurs;

.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.

.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.

.6 Space hangers and supports in accordance with following:

.1 cast iron pipe – hang or support at every joint with maximum 2.4 m (8') spacing;

.2 plastic pipe – conform to pipe manufacturer’s recommended support spacing;

.3 glass pipe – conform to pipe manufacturer’s recommended support spacing and support requirements;

.4 copper and steel pipe – hang or support at spacing in accordance with following schedule:

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
to 25 mm (1")	2.4 m (8')	1.8 m (6')
40 mm (1-½")	2.7 m (9')	2.4 m (8')
50 mm (2")	3.0 m (10')	2.7 m (9')

PIPE DIA.	MAX. SPACING STEEL (meters)	MAX. SPACING COPPER (meters)
65 mm (2-½")	3.6 m (12')	3.0 m (10')
75 mm (3")	3.6 m (12')	3.0 m (10')
90 mm (3-½")	3.6 m (12’)	3.6 m (12')
100 mm (4")	4.2 m (14')	3.6 m (12')

.5 flexible grooved pipe/coupling joint piping – as above but with not less than one hanger or support between joints;

.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.

.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.

.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.

.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:

.1 support vertical pipes at maximum 3 m (10') intervals or at every floor, whichever is lesser;

.2 for sections of vertical piping with a length less than 3 m (10'), support pipe at least once;

.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;

.4 for vertical steel pipe risers in excess of 3 m (10'), weld shear lugs to pipe to carry load;

.5 for vibration isolated piping risers, provide rubber-steel-rubber vibration isolation pads between riser clamps and floor.

.11 Support piping on the roof as follows:

.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.

.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.

.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.

.14 Do not support piping from steel deck without written consent from Consultant.

3.10 SUPPLY OF ACCESS DOORS

.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.

.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 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.

.4 Wherever possible, access doors to be of a standard size for each application. Confirm exact dimensions and minimum size restrictions with Consultant prior to ordering.

.5 Group piping and ductwork to ensure minimum number of access doors is required.

.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.

3.11 INSTALLATION OF VALVES

.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:

  .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;

  .2 install shut-off valves with handles upright or horizontal, not inverted, and located for easy access;

  .3 unless otherwise specified, provide a check valve in discharge piping of each pump;

  .4 valve sizes are to be same as connecting pipe size;

  .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;

  .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.

3.12 INSTALLATION OF PRESSURE GAUGES AND THERMOMETERS

.1 Provide pressure gauges in following locations where applicable:

  .1 in valved tubing across suction, suction strainer (if applicable), and discharge piping of each circulating pump;

  .2 in expansion tank(s);

  .3 in separate domestic hot water storage tank(s);

  .4 at top most outlet in each standpipe fire protection system riser;

  .5 in potable water service piping downstream of meter;

  .6 wherever else shown and/or specified.

.2 Provide thermometers in following locations where applicable:

  .1 in supply and return piping connections to main mechanical plant equipment such as domestic water heaters, boilers, chillers, cooling towers, heat exchangers, main coils, etc., unless temperature indication is supplied with equipment;

  .2 wherever else shown and/or specified.

.3 Conform to following installation requirements where applicable:

.1 for installation of thermometers in piping wells, provide a coat of metallic base heat transfer paste or grease in piping well;

.2 for pressure gauges in piping at equipment locations, install pressure gauge between equipment and first pipe fitting;

.3 locate, mount and adjust instruments so they are easily readable;

.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.

3.13 INSTALLATION OF EQUIPMENT DRIVE GUARDS AND ACCESSORIES

.1 Provide OHSA guards for exposed accessible rotating parts such as belt drives, couplings, fan wheels, and shaft ends on mechanical equipment.

.2 Install belt guards to allow movement of motors for adjusting belt tension.

.3 Provide a means to permit lubrication and use of test instruments with guards in place.

.4 Secure guards to equipment or equipment base but do not bridge sound or vibration isolation.

.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.

3.14 MECHANICAL WORK IDENTIFICATION

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

.1 at every end of every piping or duct run;

.2 adjacent to each valve, strainer, damper and similar accessory;

.3 at each piece of connecting equipment;

.4 on both sides of every pipe and duct passing through a floor, wall or partition, unless otherwise specified;

.5 at 6 m (20') intervals on pipe and duct runs exceeding 6 m (20') in length;

.6 at least once in each room, and at least once on pipe and duct runs less than 6 m (20') in length.

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

.1 at points where pipes or ducts enter and leave rooms, shafts, pipe chases, furred spaces, and similar areas;

.2 at maximum 6 m (20') intervals on piping and ductwork above suspended accessible ceilings, and at least once in each room;

.3 at each access door location;

.4 at each piece of connected equipment, automatic valve, etc.

.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.

.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.

.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.

.6 For electrically traced mechanical work, identification wording is to include "ELECTRICALLY TRACED".

.7 Tag valves and prepare a valve tag chart in accordance with following requirements:

.1 attach a valve tag to each new valve, except for valves located immediately at equipment they control;

.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 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;

.4 include a copy of valve tag chart in each copy of operating and maintenance instruction manuals.

.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:

.1 HVAC piping valves and equipment: yellow

.2 fire protection valves and equipment: red

.3 plumbing valves and equipment: green

.4 HVAC ductwork dampers and equipment: blue

.5 control system hardware and equipment: orange

3.15 FINISH PAINTING OF MECHANICAL WORK

.1 Finish paint exposed mechanical work as specified and/or scheduled in accordance with requirements of Division 09.

.2 Touch-up paint damaged factory applied finishes on mechanical work products.

3.16 PIPE LEAKAGE TESTING

.1 Before piping has been insulated or concealed, and before equipment, fixtures and fittings have been connected, test piping for leakage.

.2 Tests are to be witnessed by 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 When circumstances prevent scheduled tests from taking place, give immediate and adequate notice of cancellation to all who were scheduled to attend.

.4 Gravity Drainage and Vent Piping

.1 Test piping in accordance with local governing building code.

.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.

.5 Domestic Water Piping

.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.

.6 Sprinkler System Piping

.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.

.7 Steam and Condensate Piping

.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);

.8 Natural Gas Piping

.1 Test piping in accordance with requirements of CAN/CSA B149.1 and any additional requirements of local governing authorities.

.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 Check piping joints and connections for leaks with a water/soap solution while piping is under pressure.

.9 Refrigerant Piping

.1 Test refrigerant piping for leakage and dehydrate in accordance with requirements of Chapter 18 of ASHRAE Handbook - Fundamentals.

.10 Following requirements apply to all testing:

.1 ensure piping has been properly flushed, cleaned and is clear of foreign matter prior to pressure testing;

.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 when testing is carried out below highest level of the particular system, increase test pressure by the hygrostatic head of 7 kPa (1 psi) for every 600 mm (24") below the high point;

.4 include for temporary piping connections required to properly complete tests;

.5 piping under test pressure is to have zero pressure drop for length of test period;

.6 make tight leaks found during tests while piping is under pressure, and if this is impossible, remove and refit piping and reapply test until satisfactory results are obtained;

.7 where leaks occur in threaded joints in steel piping, no caulking of these joints will be allowed under any conditions;

.8 tests are be done in reasonably sized sections so as to minimize number of tests required;

.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.

3.17 ELECTRICAL WIRING WORK FOR MECHANICAL WORK

.1 Unless otherwise specified or indicated, following electrical wiring work for mechanical equipment will be done as part of the electrical work:

.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;

.2 "line" side power wiring to individual wall mounted starters, and "load" side wiring from starters to equipment;

.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;

.4 provision of receptacles for plug-in equipment;

.5 provision of disconnect switches for motors in excess of 10 m (30') from starter location, or cannot be seen from starter location, and associated power wiring;

.6 motor starter interlocking in excess of 24 volts;

.7 wiring from motor winding thermistors in motors 30 HP and larger to motor starter contacts;

.8 120 volt power connections to electrical receptacles integral with small ceiling exhaust fans, including wiring through light switches or speed controllers;

.9 120 volt wiring connections to lighting fixture/switch combinations integral with air handling units;

.10 120 volt wiring connections to duplex receptacles integral with air handling unit control panels;

.11 120 volt wiring connections to BAS system controllers/panels and other control system or component requiring 120 volt power including, but not limited to, VAV boxes, dampers, low voltage transformers, etc.

.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.

3.18 EQUIPMENT BASES AND SUPPORTS

.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:

.1 supply dimensioned drawings and equipment base templates, and provide anchor bolts for proper setting and securing of equipment on pads;

.2 place anchor bolts during concrete pour and be responsible for required levelling, alignment, and grouting of equipment;

.3 as a minimum, use wire mesh reinforcement, however, for pads for large heavy equipment, use reinforcement as per structural drawing details.

.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:

.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;

.2 flange bolt steel stands to concrete housekeeping pads;

.3 seismically restrained stands and supports in accordance with applicable requirements.

3.19 CONCRETE WORK FOR MECHANICAL EQUIPMENT BASES/PADS

.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.

.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 Building Code.

.3 Ensure that bases and pads are keyed into the structure to meet seismic restraint requirements where applicable.

3.20 EXCAVATION AND BACKFILL WORK

.1 Unless otherwise specified in Division 31, provide all excavation and backfill associated with the mechanical scope of work.

.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 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.

.4 Where Work falls under jurisdiction of local governing utility, confirm requirements and comply with utility requirements.

.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 Consultant. Depth of excavations must accommodate local governing requirements and local standard practices to compensate for local frost levels of Place of the Work.

.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.

.7 In firm, undisturbed soil, lay pipes directly on soil, unless otherwise directed.

.8 Before backfilling, arrange for inspection of work by Consultant. Do not backfill work unless reviewed with Consultant. Failure to do so prior to backfilling will require re-excavating work and re-backfill at no additional cost to Owner.

.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.

.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.

.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.

.12 Provide minimum 1.37 m (4.5') of cover for underground piping subject to freezing and located outside building.

.13 Provide minimum 450 mm (18") of cover for underground piping subject to freezing and located inside building.

.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.

.15 Unless otherwise directed in Division 02 and/or Division 31, store and dispose of excavated materials as follows:

  .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;

  .2 separately place surplus topsoil and subsoil as directed; leave site clean and unencumbered.

.16 Perform pumping as required to keep excavations free of water.

.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 Consultant for review.

.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.

.19 Coordinate requirements for final surface toppings (concrete, asphalt, pavers, grass sod, etc.) with General Contractor.

3.21 CUTTING, PATCHING AND CORE DRILLING

.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 Consultant.

.2 Criteria for cutting holes for additional services:

  .1 cut holes through slabs only; no holes to be cut through beams;

  .2 cut holes 150 mm (6") diameter or smaller only; obtain approval from Structural Consultant for larger holes;

  .3 keep at least 100 mm (4") clear from beam faces;

  .4 space at least 3 hole diameters on centre;

  .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;

  .6 for holes that are required within 50% of slab span, use cover meter underside of slab to clear slab bottom bars;

  .7 submit sleeving drawings indicating holes and their locations for Structural Consultant's review.

.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.

.4 Where pipes pass through existing construction, core drill an opening. Size openings to leave 12 mm (½") clearance around pipes or pipe insulation.

.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.

.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 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.

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

3.22 FLASHING FOR MECHANICAL WORK PENETRATING ROOF

.1 Unless otherwise specified in Division 07, perform required flashing work, including counter-flashing, for mechanical work penetrating and/or set in roof.

.2 Perform flashing work in accordance with requirements of drawing details and/or requirements specified in Division 07.

3.23 CLEANING MECHANICAL WORK

.1 Refer to cleaning requirements specified in Division 01.

.2 Clean mechanical work prior to application for Substantial Performance of the Work.

.3 Include for vacuum cleaning interior of air handling units and ductwork systems.

3.24 CONNECTIONS TO OTHER EQUIPMENT

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

3.25 SEISMIC RESTRAINT ANCHOR POINTS FOR EQUIPMENT

.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.

.2 Equipment to be restrained must be designed such that the strength and anchorage of the internal components of equipment exceeds force level used to restrain and anchor equipment itself to the supporting structure.

3.26 INSTALLATION OF FLEXIBLE CONNECTORS

.1 Provide flexible connectors in piping connections to seismically restrained equipment, where applicable, and wherever else shown.

.2 Provide flexible connectors in piping connections to vibration isolated equipment.

3.27 FAN NOISE LEVELS

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

3.28 EQUIPMENT AND SYSTEM MANUFACTURER'S CERTIFICATION

.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 Consultant that equipment/system installation is complete and in accordance with equipment/system manufacturer's instructions.

3.29 EQUIPMENT AND SYSTEM START-UP

.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:

- .1 submit a copy of each equipment/system manufacturer's start-up report sheet to Consultant for review, and incorporate any comments made by Consultant;
- .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 Consultant complete set of start-up documentation sheets signed by manufacturer/supplier and Contractor.

End of Section

1 General

1.1 REFERENCES

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

1.2 APPLICATION

.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 Divisions 00 or 01, conditions of Division 00 or Division 01 to take precedence.

.2 Be responsible for advising product vendors of requirements of this Section.

1.3 DEFINITIONS

.1 "concealed" – means hidden from normal sight in furred spaces, shafts, ceiling spaces, walls and partitions.

.2 "exposed" – means work normally visible, including work in equipment rooms, service tunnels, and similar spaces.

.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.

.4 "provision" or "provide" (and tenses of "provide") – means supply and install complete.

.5 "install" (and tenses of "install") – means secure in position, connect complete, test, adjust, verify and certify.

.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.

.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 Consultant.

.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.

.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.

.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.

.11 "Mechanical Divisions" – refers to Divisions 20, 21, 22, 23, 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.

.12 "Electrical Divisions" – refers to Divisions 26, 27, 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.

.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.

.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.

.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 Documents for bidding include but are not limited to issued Drawings, Specifications and Addenda.

.2 Specification is arranged in accordance with CSI/CSC 49 Divisions of MasterFormat.

.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.

.4 Review Drawings and Specifications in conjunction with documents of other Divisions and, where applicable, Code Consultant’s report.

.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.

.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.

.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.

.8 Locations of equipment and materials shown may be altered, when reviewed by 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.

.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.

.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.

.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 Consultant to any other party.

.12 When scale and date of Drawings are the same, or when discrepancy exists within Specification, include most costly arrangement to take precedence.

.13 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 drawings are same, or where discrepancy exists within specification, most costly arrangement will take precedence. In not specified in “General Conditions”, documents will govern in the following order:

  .1 Specification;

  .2 Drawings of larger scale;

  .3 Drawings of smaller scale;

.4 Drawings of later date when scale of Drawings is same.

1.5 METRIC AND IMPERIAL MEASUREMENTS

.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 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.

.2 Report to Purchasing Representative, 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.

.3 Upon finding discrepancies in, or omissions from Documents, or having doubt as to their meaning or intent, immediately notify Purchasing Representative, in writing.

1.7 WORK STANDARDS

.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.

.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 Consultant.

.3 Supplementary mandatory specification and requirements to be used in conjunction with project include but are not limited to following:

.1 Air-Conditioning, Heating and Refrigeration Institute (AHRI);

.2 Air Movement and Control Association (AMCA);

.3 American Iron and Steel Institute (AISI);

.4 American National Standards Institute (ANSI);

.5 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., (ASHRAE);

.6 American Society of Mechanical Engineers (ASME);

.7 American Society of Testing and Materials (ASTM);

.8 American Water Works Association (AWWA);

.9 Associated Air Balance Council (AABC);

.10 Building Industry Consulting Services, International (BICSI);

.11 Canadian Gas Association (CGA);

.12 Canadian General Standards Board (CGSB);

.13 Canadian Standards Association (CSA);

.14 Electrical and Electronic Manufacturers Association of Canada (EEMAC);

.15 Electrical Safety Authority (ESA);

.16 Electronic Industries Association (EIA);

.17 Factory Mutual Systems (FM);

.18 Illuminating Engineering Society (IES);

.19 Institute of Electrical and Electronic Engineers (IEEE);

.20 International Standards Organization (ISO);

.21 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS);

.22 National Building Code of Canada (NBC);

.23 National Electrical Manufacturers Association (NEMA);

.24 National Environmental Balancing Bureau (NEBB);

.25 National Fire Protection Association (NFPA);

.26 National Standards of Canada;

.27 NSF International;

.28 Occupational Health and Safety Act (OHSA);

.29 Ontario Building Code (OBC);

.30 Ontario Electrical Safety Code (OESC);

.31 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA);

.32 Technical Standards and Safety Authority (TSSA);

.33 Thermal Insulation Association of Canada (TIAC);

.34 Underwriters' Laboratories of Canada (ULC);

.35 Workplace Hazardous Materials Information System (WHMIS);

.36 Material Safety Data Sheets by product manufacturers;

.37 Local utility inspection permits;

.38 Codes, standards, and regulations of local governing authorities having jurisdiction;

.39 Additional codes and standards listed in Trade Sections;

.40 Owner's standards.

.4 Provide applicable requirements for barrier free access in accordance with latest edition of local governing building code.

.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.

.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.

.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.

.8 Journeyperson tradesmen are to have a copy of valid trade certificates available at site for review with Consultant at any time.

.9 Experienced and qualified superintendent is to be on-site at times when work is being performed.

.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 Consultant and submission of reports and certificates to Consultant.

.11 Properly protect equipment and materials on site from damage due to elements and work of trades, to satisfaction of Owner and reviewed with Consultant. Equipment and materials are to be in new condition upon Substantial Performance of the Work.

.12 Mechanical piping system work, including equipment, must comply in all respects with requirements of local technical standards authorities and CSA B51, Boiler, Pressure Vessels and Pressure Piping Code. Where required, mechanical work products must bear a CRN number.

.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 Contact and confirm with local authorities having jurisdiction including utility providers, requirements for approvals from such authorities. Obtain and pay for all permits other than building permit, certificates, and approvals required to complete Work. Sprinkler permit to be applied for by GC.

.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.

.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.

.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 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. General contractor is responsible for ensuring all sub-contractors and sub-consultants maintain proper insurance.

.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.

.3 Unless otherwise specified in Division 00 or 01, liability insurance requirements are as follows:

- .1 coverage is to be a minimum of $1,000,000.00 CDN inclusive of any one occurrence;
- .2 insurance policy is not to be cancelled or changed in any way without insurer giving Owner minimum thirty days written notice;
- .3 liability insurance is to be obtained from an insurer registered and licensed to underwrite such insurance in the Place of the Work;
- .4 retained consultants are to ascertain that sub-consultants employed by them carry insurance in the form and limits specified above;

.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 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.

.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.

1.11 PLANNING AND LAYOUT OF WORK

.1 Base installation layout, design, terminations, and supply of accessories, on Contract Documents with specific coordination with reviewed shop drawings.

.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 piping requiring uniform pitch;

.2 piping 100 mm (4") dia. and larger;

.3 large ducts (main runs);

.4 cable tray and bus duct;

.5 conduit 100 mm (4") dia. and larger;

.6 piping less than 100 mm (4") dia.;

.7 smaller branch ductwork;

.8 conduit less than 100 mm (4") dia..

.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.

.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.

.5 Prepare plan and interference drawings (at a minimum drawing scale of 1:50 or ¼"=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 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.

.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.

.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.

.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 COORDINATION OF WORK

.1 Review Contract Documents and coordinate work with work of each trade. Coordination requirements are to include but not be limited to following:

.1 requirements for openings, sleeves, inserts and other hardware necessary for installation of work;

.2 concrete work such as housekeeping pads, sumps, bases, etc., required for work, and including required dimensions, operating weight of equipment, location, etc.;

.3 depth and routing of excavation required for work, and requirements for bedding and backfill;

.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.

.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.

.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.

.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.

.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.

1.13 PRODUCTS

.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.

.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.

.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.

.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 acceptable 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 acceptable manufacturers are not stated for a particular product, base Bid Price on product supplied by base specified manufacturer.

.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 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 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.

.6 Listing of a product as "acceptable" does not imply automatic acceptance by 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.

.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.

.8 In addition to manufacturer's products base specified or named as acceptable, other manufacturers of products may be proposed as substitutions to 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 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. Do not order such products until they are accepted in writing by Consultant.

.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 Consultant, provide full design detail drawings and specifications of proposed products. Acceptance of these "or approved equal" products is at sole discretion of 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.

.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 Consultant for review. Failure of submission of these documents to 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.

.11 Substitution of products supplied by a manufacturer not named as acceptable is not allowed during bid period.

.12 Any proposed changes initiated by Contractor after award of Contract may be considered by Consultant at Consultant's discretion, with any additional costs for such changes if accepted by Owner and reviewed with Consultant, and costs for review, to be borne by Contractor.

.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.

1.14 SHOP DRAWINGS

.1 At start-up meeting, review with Consultant products to be included in shop drawing submission. Prepare and submit list of products to Consultant for review.

.2 Submit electronic copies of shop drawings unless otherwise directed by Consultant. Coordinate exact requirements with Consultant.

.3 Submit for review, drawings showing detail design, construction, and performance of equipment and materials as requested in Specification. Submit shop drawings to Consultant for review prior to ordering and delivery of product to site. Include minimally for preparation and submission of following, as applicable:

- .1 product literature cuts;
- .2 equipment data sheets;
- .3 equipment dimension drawings;
- .4 system block diagrams;
- .5 sequence of operation;
- .6 connection wiring schematic diagrams;
- .7 functionality with integrated systems.

.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.

.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.

.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.

.7 Consultant to review shop drawings and indicate review status by stamping shop drawing copies as follows:

- .1 "REVIEWED" or "REVIEWED AS NOTED" (appropriately marked) – If Consultant's review of shop drawing is final, Consultant to stamp shop drawing;
- .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.

.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 "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."

.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.

.10 Obtain shop drawings for submission from product manufacturer's authorized representatives and supplemented with additional items specified herein.

.11 Do not order product until respective shop drawing review process has been properly reviewed with Consultant.

.12 Where extended warranties are specified for equipment items, submit specified extended warranty with shop drawing submittal.

.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.

1.15 EQUIPMENT LOADS

.1 Supply equipment loads (self-weight, operating weight, housekeeping pad, inertia pads, etc.) to Consultant, via shop drawing submissions, prior to construction.

.2 Where given choice of specific equipment, actual weight, location and method of support of equipment may differ from those assumed by Consultant for base design. Back-check equipment loads, location, and supports, and include necessary accommodations.

.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 Consultant prior to construction.

1.16 OPENINGS

.1 Supply opening sizes and locations to Consultant to allow verification of their effect on design, and for inclusion on structural drawings where appropriate.

.2 No openings are permitted through completed structure without written approval from Owner and reviewed with Consultant. Show required openings on a copy of structural drawings. Identify exact locations, elevations, and size of proposed openings and submit to Consultant for review, well in advance of doing work.

.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 Consultant, do not leave any openings unprotected and unfinished overnight.

1.17 SCAFFOLDING, HOISTING AND RIGGING

.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 Consultant.

.2 Immediately remove from site scaffolding, rigging and hoisting equipment when no longer required.

.3 Do not place major scaffolding/hoisting equipment loads on any portion of structure without approval from Owner and reviewed with Consultant.

1.18 CHANGES IN THE WORK

.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 Consultant for review, a quotation being proposed cost for executing change or revision.

.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.

.3 Unless otherwise specified in Division 00 or 01, allowable maximum percentages for overhead and profit are to be 7% and 5% respectively.

.4 Unless otherwise specified in Divisions 00 or 01, following additional requirements apply to all quotations submitted:

  .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;

  .2 material costs are not to exceed those published in local estimating price guides;

  .3 mechanical material labour unit costs are to be in accordance with Mechanical Contractors Association of America Labor Estimating Manual, less 25%;

  .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%;

  .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;

  .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;

  .7 costs for rental tools and/or equipment are not to exceed local rental costs;

  .8 overhead percentage will be deemed to cover quotation costs other than actual site labour and materials, and rentals;

  .9 quotations, including those for deleted work, to include a figure for any required change to Contract time.

.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.

.6 Make requests for changes or revisions to work to Consultant in writing and, if Consultant agrees, will issue Notice of Change.

.7 Do not execute any change or revision until written authorization for the change or revision has been obtained from Consultant.

1.19 PROGRESS PAYMENT BREAKDOWN

.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.

.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.

.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.

1.20 NOTICE FOR REQUIRED FIELD REVIEWS

.1 Whenever there is a requirement for 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 Consultant.

.2 If Consultant is unable to attend a field review when requested, arrange an alternative date and time.

.3 Do not conceal work until Consultant advises that it may be concealed.

.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.

1.21 PRELIMINARY TESTING

.1 When directed by 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.

.2 When, in Consultant’s opinion, tests are required to be performed by a certified testing laboratory, arrange and pay for such tests.

.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.

.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.

1.22 PROVISIONS FOR SYSTEMS/EQUIPMENT USED DURING CONSTRUCTION

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

1.23 TEMPORARY SERVICES

.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.

.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.

1.24 MAINTAINING EQUIPMENT PRIOR TO ACCEPTANCE

.1 Maintain equipment in accordance with the manufacturer's printed instructions prior to start-up, testing and commissioning.

.2 Employ a qualified millwright to check and align shafts, drives, and couplings on all base mounted split coupled motor driven equipment.

.3 Where equipment lubrication fittings are not easily accessible, extend the fittings to accessible locations using copper or aluminium tubing.

.4 All filters are to be new upon Substantial Performance of the Work. This is in addition to any spare filters specified.

1.25 CLEANING

.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.

.2 Clean equipment and devices installed as part of this project.

1.26 RECORD AS-BUILT DRAWINGS

.1 Drawings for this project have been prepared on a CAD system using Revit R20. For purpose of producing record "as built" drawings, copies of Contract Drawings can be obtained from Consultant.

.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 dimensioned location of inaccessible concealed work;
- .2 locations of control devices with identification for each;
- .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;
- .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;
- .5 location of piping system air vents;
- .6 location of concealed services terminated for future extension and work concealed within building in inaccessible locations.

.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 Consultant for review. Make necessary revisions to drawings as per Consultant’s comments, to satisfaction of Consultant.

.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 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.

.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 Consultant.

.6 Unless otherwise noted in Divisions 00 or 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 Consultant.

.7 For projects with phased turnover of project (refer to Division 01), review with 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.

.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.

1.27 OPERATING AND MAINTENANCE MANUALS

.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 front cover: project name; wording – "Mechanical Systems Operating and Maintenance Manual"; and date;

.2 introduction sheet listing Consultant, Contractor, and Subcontractor names, street addresses, telephone and fax numbers, and e-mail addresses;

.3 equipment manufacturer's authorized contact person name, telephone number and company website;

.4 Table of Contents sheet, and corresponding index tab sheets;

.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;

.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.

.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.

.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.

.9 copies of warranties;

.10 items requested specifically in Section Articles.

.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.

.3 Before applying for a Certificate of Substantial Performance of the Work, assemble one copy of O & M Manual and submit to Consultant for review prior to assembling remaining copies. Incorporate Consultant's comments into final submission.

1.28 COMMISSIONING

.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 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.

.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.

.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.

.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 Unless otherwise specified in Divisions 00 and 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.

.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 Consultant.

.3 Warranty to include parts, labour, travel costs and living expenses incurred by manufacturer’s authorized technician to provide factory authorized on-site service.

.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.

.5 Do not include Owner deductible amounts in warranties.

.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 responsible for providing whatever "bridging" or additional extended warranty period is required from time that material is purchased until this time.

.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 once during 1st month of building operation;

.2 once during 3rd month of building operation;

.3 once between 4th and 10th month in a season opposite to 1st and 3rd month visits.

1.30 PROJECT CLOSEOUT SUBMITTALS

.1 Prior to application for Substantial Performance of the Work, submit required items and documentation specified, including following as applicable to the project:

.1 Operating and Maintenance Manuals;

.2 as-built record drawings and associated data;

.3 extended warranties for equipment as specified;

.4 operating test certificates, i.e. Sprinkler Test Certificate;

.5 final commissioning report and TAB report;

.6 identified keys for equipment and/or panels for which keys are required, and other items required to be submitted;

.7 other data or products specified.

1.31 INSTRUCTIONS TO OWNER

.1 Refer to equipment and system operational and maintenance training requirements specified in Division 01.

.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.

.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.

.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 Operational Requirements and Criteria – equipment function, stopping and starting, safeties, operating standards, operating characteristics, performance curves, and limitations;

.2 Troubleshooting – diagnostic instructions, test and inspection procedures;

.3 Documentation – equipment/system warranties, and manufacturer’s/supplier’s parts and service facilities, telephone numbers, email addresses, and the like;

.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;

.5 Repairs – diagnostic instructions, disassembly, component removal and repair instructions, instructions for identifying parts and components, and review of any spare parts inventory.

.5 Before instructing Owner’s designated personnel, submit to 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.

.6 Obtain in writing from 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 date instructions were given to Owner’s staff;

.2 duration of instruction;

.3 names of persons instructed;

.4 other parties present (manufacturer’s representative, consultants, etc.).

.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.

.8 Submit to Consultant copy of electronic version of training materials and include in operating and maintenance manuals submission.

1.32 FINAL INSPECTION

.1 Submit to Consultant, written request for final inspection of systems. Include written certification that:

.1 deficiencies noted during job inspections have been completed;

.2 field quality control procedures have been completed;

.3 systems have been tested and verified, balanced and adjusted, and are ready for operation;

.4 maintenance and operating data have been completed and submitted to, reviewed with Consultant and accepted by Owner;

.5 tags and nameplates are in place and equipment identifications have been completed;

.6 clean-up is complete;

.7 spare parts and replacement parts specified have been provided and acknowledged by Consultant;

.8 as-built and record drawings have been completed and submitted to and reviewed with Consultant and accepted by Owner;

.9 Owner’s staff has been instructed in operation and maintenance of systems;

.10 commissioning procedures have been completed.

2 Products – Not Used

3 Execution – Not Used

End of Section

1 General

1.1 SUBMITTALS

.1 Shop Drawings/Product Data: Submit shop drawings with product data sheets for variable frequency drives (VFDs). Include:

- .1 construction and performance details;
- .2 wiring and control schematics;
- .3 dimensions of units;
- .4 calculations specific to installation showing total harmonic voltage distortion is less than 5%;
- .5 certified production test results with serial numbers for harmonic mitigation performance and energy efficiency under actual variable frequency drive loading.

.2 Certification Letter: Submit a start-up and installation certification letter from supplier of VFDs as specified in Part 3 of this Section;

.3 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 Consultant.

.4 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.

.5 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 COORDINATION WITH ELECTRICAL DIVISIONS

.1 This Section specifies VFD requirements for motors. Ensure that VFDs packaged with various system equipment, complies with specifications of this Section.

.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.

.3 Coordinate and review with Electrical Divisions, responsibility requirements for supply of VFDs, harmonic filters and requirements for control and power conductors and connections.

.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.

.5 Additionally, review and confirm responsibilities with Consultant and Prime Contractor.

2 Products

2.1 VFD BASIC REQUIREMENTS

.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:

- .1 CSA C22.2 No.14 Industrial Control Equipment;
- .2 UL 508 - Industrial Control Equipment;
- .3 UL 508C – Power Conversion Equipment;
- .4 NEMA ICS 7 - Adjustable-Speed Drives.

.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.

.3 VFDs to include following basic requirements:

- .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 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);
- .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;
- .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;
- .5 provisions that determines motor torque and flux every 25 microseconds (40,000 times per second);
- .6 completely assembled and tested by manufacturer in their facility;
- .7 designed to provide at least 250,000 hours mean time before failure (MTBF) when specified preventative maintenance is performed.
- .8 door interlocked padlockable disconnect switch that disconnects all input power from drive and all internally mounted options;
- .9 control panel keyboard and display with password protection against parameter changes.

2.2 VFD RATINGS

.1 VFDs to be rated to operate from 3 phase input voltage of 208 or 600 volts ± 10%, as scheduled, and frequency range from 48 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 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.

.3 VFDs efficiency to be 96% or better at full speed and load.

.4 Output voltage and current ratings to match adjustable frequency operating requirements of standard 3ph, 60Hz, NEMA design B inverter-duty motors in compliance with NEMA-MG1, 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.

.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.

.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.

.7 Enclosures:

- .1 in climate controlled areas – minimum NEMA 12 with drip shield;
- .2 in non-climate controlled areas – NEMA 3R.

2.3 HARMONIC FILTERS AND REACTORS

.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.

2.4 CONTROLS AND ADJUSTMENT FUNCTIONS

.1 Include for following:

.1 programmable critical frequency lockout ranges to prevent VFD from operating load continuously at an unstable speed;

.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 (ie. valves, dampers, etc.); set points, process variables, etc. to be accessible from serial communication network;

.3 programmable analogue inputs that accept current or voltage signals.

.4 programmable analogue outputs (0-20ma 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;

.5 programmable digital inputs;

.6 programmable digital Form-C relay contact outputs for programmable on and off delay times and adjustable hysteresis; rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS;

.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;

.8 two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps;

.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 Operator Control Panel:

.1 front mounted plug-in operator control panel consisting of keypad, multi-line backlit LCD display for programming and fault diagnostics;

.2 keys (switches) for HAND, OFF, AUTO, and manual speed control INCREASE/DECREASE;

.3 menu navigation and parameter selection keys for custom programming;

.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 l automatically reverts to hours of operation since initial power up; clock also to be programmable to control 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;

.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:

.1 Output Frequency;

.2 Motor Speed (RPM, %, or Engineering units);

.3 Motor Current;

.4 Drive Temperature;

.5 DC Bus Voltage;

.6 Output Voltage.

2.5 PROTECTIVE FUNCTIONS

.1 For each programmed warning and fault protection function, keypad displays a message in complete words or standard abbreviations.

.2 VFDs include metal oxide varistors (MOV's) for phase to phase and phase to ground line voltage transient protection.

.3 Short circuit current rating of 100,000 amps to be provided per UL 508C without relying on line fuses.

.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.

.5 VFDs to provide electronic motor overload protection qualified per UL 508C.

.6 Protection to be provided for AC line or DC bus overvoltage at 130% of maximum rated or undervoltage at 65% of minimum rated.

.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.

.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.

.9 Overtemperature protection to provide a warning if power module temperature is less than 5C° (9F°) below overtemperature trip level.

.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.

.11 VFDs through 56 kW (75HP) to be protected from damage from input and output power miss-wiring. VFD to sense this condition and display an alarm on control panel.

.12 EMI / RFI filters to be provided as per standard EN 61800-3.

.13 dv/dt long lead filter (LRC) to protect power system network.

.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:

.1 Overcurrent;

.2 Overvoltage;

.3 Undervoltage;

.4 Analogue input signal reference loss;

.5 External fault.

.15 Additional built-in protection circuits include:

.1 Overcurrent trip limit;

.2 Undervoltage trip limit;

.3 Microprocessor fault;

.4 Keypad control panel loss;

.5 Serial communication loss;

.6 External fault interlock inputs;

.7 Adjustable output frequency and motor speed limits;

.8 Pass code parameter change protection;

.9 Keypad operator control lockout.

2.6 COMMUNICATIONS

.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 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:

.1 BACnet.

.3 Serial communication to be used for drive setup, diagnostic analysis, monitoring and control with capabilities to include, but not be limited to:

.1 run-stop control;

.2 speed set adjustment;

.3 proportional/integral/derivative PID control adjustments;

.4 current limit;

.5 accel/decel time adjustments;

.6 ability to lock and unlock control panel keypad;

.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;

.8 monitoring relays output status, and digital input status and analogue output values;

.9 transmitting diagnostic warning and fault information over communications bus to BAS or other monitoring system;

.10 remote fault reset.

2.7 WARRANTY

.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.

2.8 SITE SERVICES, TRAINING, AND MAINTENANCE MANUALS

.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 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.

.3 Provide system training and instructions on operating and maintenance procedures. Refer to additional requirements in General Instructions section and Division 01.

2.9 ACCEPTABLE MANUFACTURERS

.1 Acceptable VFD manufacturers are:

.1 ABB;

.2 Schneider Electric (Square D);

.3 Rockwell Automation;

.4 Eaton Cutler Hammer;

.5 Siemens Electric;

.6 Control Techniques.

3 Execution

3.1 INSTALLATION OF VARIABLE FREQUENCY DRIVES

.1 Provide variable frequency drives for motorized equipment in accordance with drawing requirements. Coordinate requirements for conductors and connections with Electrical Divisions Contractor.

.2 Ensure that variable speed drives supplied are products of same manufacturer.

.3 Ensure wire length between VFD and motor is less than 15 m (50') with properly sized conductors.

.4 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.

.5 Review VFD and related connected motor installation. Provide local disconnect to VFD in accordance with local governing code requirements.

.6 Mount VFDs operating controls/display at approximately 1.5 m (5') above finished floor level, unless otherwise directed by 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.

.7 Properly support VFDs. Coordinate exact locations on site with Consultant.

.8 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.

.9 Ground and bond equipment as per local governing electrical code requirements and manufacturer's instructions.

.10 Provide engraved lamacoid nameplate identifying each piece of equipment. Review exact nomenclature with Consultant.

.11 Be responsible for ensuring that VFDs and connected motors are properly installed, connected, tested in proper working order and operation verified.

3.2 TESTING, START-UP, AND VERIFICATION

.1 When installation of VFDs are complete, arrange for VFD manufacturer/supplier to:

  .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;

  .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 prepare and submit letter to certify that VFDs have been properly installed, tested and adjusted, and are in proper operating condition;

  .4 submit list of start-up and testing parameters for uploading for future use by Owner.

.2 Start-up data entries to include motor nameplate power, speed, voltage, frequency and current.

.3 Inspect VFDs and accessories for verification of proper operation and installation.

.4 Inspect interface wiring to BAS for verification of proper operation and installation.

.5 Verification of wire terminations to VFDs and bypass and to operational circuitry.

.6 Installation verification of VFD, bypass and motor being driven for proper operation and reliability.

.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.

.8 Measurement for verification of proper operation on each of following items:

  .1 Motor voltage and frequency;

  .2 Verification of proper motor operation;

  .3 Control input for proper building automation system interface and control calibration.

.9 Calibration check for following set points (and adjustment as necessary):

  .1 minimum speed;

  .2 maximum speed;

  .3 acceleration and deceleration rates.

.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.

.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 Consultant for review.

.12 Additionally, refer to applicable installation, testing, coordination and verification requirements in Electrical Divisions Sections.

End of Section

1 General

1.1 APPLICATION

.1 This Section specifies firestopping and smoke seal 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 Submit a product data sheet and a WHIMIS sheet for each firestopping and smoke seal product.

.2 Submit for review, full company name and experience of proposed firestopping and smoke seal system applicator.

.3 Submit a letter of proper firestopping and smoke seal certification as specified in Part 3 of this Section.

1.3 QUALITY ASSURANCE

.1 Applicator is to have a minimum of 3 years of successful experience on projects of similar size and complexity, and applicator's qualifications are to be reviewed by Consultant.

.2 Comply with firestopping and smoke seal product manufacturer’s recommendations regarding suitable environment conditions for product installation.

2 Products

2.1 FIRESTOPPING AND SMOKE SEAL SYSTEM MATERIALS

.1 Ensure all sealant and fire stopping is low VOC type in accordance with LEED.

.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.

.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.

.4 Pipe insulation forming part of a fire and smoke seal assembly is specified in Section entitled Mechanical Insulation.

.5 Acceptable manufacturers are:

- .1 A/D Fire Protection Systems "FIREBARRIER";
- .2 Tremco Inc. Fire Protection Systems Group "TREMSTOP";
- .3 3M Canada;
- .4 Hilti (Canada) Ltd. Firestop Systems;
- .5 Specified Technologies Inc.

3 Execution

3.1 INSTALLATION OF FIRESTOPPING AND SMOKE SEAL MATERIALS

.1 Where mechanical work penetrates fire rated construction, provide ULC listed and labelled firestopping and smoke seal materials installed in accordance with requirements of ULC S115, ULC S101, and other governing authorities to seal penetrations.

.2 Abide by following requirements:

- .1 Examine substrates, openings, voids, adjoining construction and conditions under which firestop and smoke seal system is to be installed. Confirm compatibility of surfaces.

.2 Verify penetrating items are securely fixed and properly located with proper space allowance between penetrations and surfaces of openings.

.3 Report any unsuitable or unsatisfactory conditions to Contractor and Consultant in writing, prior to commencement of work. Commencement of work will mean acceptance of conditions and surfaces.

.4 Mask where necessary to avoid spillage and over coating onto adjoining surfaces. Remove stains on adjacent surfaces.

.3 Conform to following application requirements:

.1 Prime substrates in accordance with product manufacturer’s written instructions.

.2 Provide temporary forming as required and remove only after materials have gained sufficient strength and after initial curing.

.3 Tool or trowel exposed surfaces to a neat, smooth, and consistent finish.

.4 Remove excess compound promptly as work progresses and upon completion.

.5 At fusible link damper locations, seal perimeter of angle iron framing on both sides of wall or slab with ULC listed and labelled sealant materials to provide a positive smoke seal.

.4 Notify Consultant when work is complete and ready for inspection, and prior to concealing or enclosing firestopping and smoke seal materials and service penetration assemblies. Arrange for final inspection of work by Municipal Building Inspector prior to concealing or enclosing work. Make any corrections required.

.5 On completion of firestopping and smoke sealing installation, submit a Letter of Assurance to Consultant certifying the firestopping and smoke sealing installation has been carried out throughout the building to mechanical service penetrations and that installation has been done in strict accordance with requirements of Provincial Building Code, any applicable local Municipal Codes, ULC requirements, and manufacturer’s instructions.

End of Section

1 General

1.1 APPLICATION

.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 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.

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

1.3 SEISMIC RESTRAINT REQUIREMENTS

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

2 Products

2.1 GENERAL

.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 Springs are to be stable, colour coded, selected to operate at no greater than ⅔ 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.

.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.

.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.

.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 entitled Seismic Control and Restraint.

.6 Flexible piping connections to vibration isolated equipment are specified in the appropriate piping sections of the Specification.

2.2 ISOLATION PADS

.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 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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type NSN;

.2 The VMC Group Vibration Mounting & Controls Inc. (Korfund-Dynamics) "SHEAR-FLEX PLATES";

.3 Kinetics Noise Control Vibron Products Group Type NGS/NGD;

.4 Mason Industries Inc. Type SW/S/SW with HG Bolt Insertion Washers;

.5 J. P. America Inc. Type JSJ.

2.3 RUBBER FLOOR ISOLATORS

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type R;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type RSM;

.3 Kinetics Noise Control Vibron Products Group Type RQ;

.4 Mason Industries Inc. Type BR;

.5 J. P. America Inc. Type TRM.

2.4 SPRING FLOOR ISOLATORS

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type SFS;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type AMSR;

.3 Kinetics Noise Control Vibron Products Group Type FLSS;

.4 Mason Industries Inc. Type SSLFH;

.5 J. P. America Inc. Type TSO-C-SC.

2.5 OPEN SPRING MOUNTS

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type FS;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Type A;

.3 Kinetics Noise Control Vibron Products Group Type FDS;

.4 Mason Industries Inc. Type SLFH;

.5 J. P. America Inc. Type TSO.

2.6 CLOSED SPRING MOUNTS

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type CM;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Types B and C;

.3 Kinetics Noise Control Vibron Products Group Type FLS;

.4 Mason Industries Inc. Type C;

.5 J. P. America Inc. Type TSC.

2.7 TOTALLY RETAINED SPRING MOUNTS

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type CSR;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Type MS;

.3 Kinetics Noise Control Vibron Products Group Type SM;

.4 Mason Industries Inc. Type SLRSO;

.5 J. P. America Inc. Type TSR.

2.8 SPRING HANGERS

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type SHR-SN;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) "Spring-Flex" Series HRSA;

.3 Kinetics Noise Control Vibron Products Group. Type SRH;

.4 Mason Industries Inc. Type 30N;

.5 J. P. America Inc. Type TSH.

2.9 NEOPRENE HANGER ISOLATORS

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type NH;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type HR;

.3 Kinetics Noise Control Vibron Products Group Type RH;

.4 Mason Industries Inc. Type HD or WHD;

.5 J. P. America Inc. Type TRH.

2.10 CONCRETE INERTIA TYPE EQUIPMENT BASE

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type CIB;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type CPF;

.3 Kinetics Noise Control Vibron Products Group. Type CIB;

.4 Mason Industries Inc. Type KSL;

.5 J. P. America Inc. Type BCI.

2.11 STEEL EQUIPMENT BASE

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type SB;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type WFB;

.3 Kinetics Noise Control Vibron Products Group Type SFB;

.4 Mason Industries Inc. Type WFSL;

.5 J. P. America Inc. Type BWS (with motor slide rail).

2.12 COMBINATION STEEL /CONCRETE INERTIA EQUIPMENT BASE

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type CIB (with motor slide rails);

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type WPF (with motor slide rails);

.3 Kinetics Noise Control Vibron Products Group Type CIB (with motor slide rails);

.4 Mason Industries Inc. Type BMK or K;

.5 J. P. America Inc. Type BSI (with motor slide rail).

2.13 SLUNG STEEL BASE

.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 Acceptable products are:

.1 Vibro-Acoustics Ltd. Type SS;

.2 The VMC Group Vibration Mounting & Controls (Korfund-Dynamics) Type CPF;

.3 Kinetics Noise Control Vibron Products Group Type CIB-H;

.4 Mason Industries Inc. Type MSL.

3 Execution

3.1 INSTALLATION OF VIBRATION ISOLATION MATERIALS

.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.

.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 Unless otherwise specified, vibration isolation products are to be product of one manufacturer.

.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.

.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:

- .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;
- .2 steel bases are to clear the sub-base by 25 mm (1");
- .3 concrete bases are to clear the sub-base by 50 mm (2").

.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:

- .1 for pipe less than or equal to 100 mm (4") dia. – first 3 points of support;
- .2 for pipe 125 mm (5") to 200 mm (8") dia. – first 4 points of support;
- .3 for pipe equal to or greater than 250 mm (10") dia. – first 6 points of support;

.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").

.8 Secure top of spring hanger frame rigidly to structure, and do not install spring hangers in concealed locations.

.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.

.10 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 Consultant.

.11 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.

.12 Refer to Section entitled Seismic Control and Restraint for requirements pertaining to seismically restrained vibration isolation.

End of Section

1 General

1.1 APPLICATION

.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 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.

.2 Seismic Consultant is to:

- .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;
- .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;
- .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 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.

.2 Submit copies of Seismic Consultant's Letters of Assurance as specified above.

.3 Submit copies of Seismic Consultant and seismic control manufacturer's certification letters as specified in Part 3 of this Section.

.4 If requested, submit samples of seismic restraint materials for review.

1.4 QUALITY ASSURANCE

.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.

.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.

.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.

.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.

.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

.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 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.

.3 Where impact forces may be significant, use ductile materials.

.4 Seismic restraining devices factory supplied with equipment are to meet requirements of this Section.

.5 Acceptable manufacturers are:

.1 Mason Industries Inc.;

.2 Kinetics Noise Control;

.3 Vibro-Acoustics Ltd;

.4 Price Industries Inc.

2.2 SLACK CABLE RESTRAINTS

.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.

2.3 ANCHOR BOLTS

.1 Equal to Mason Industries type SAB seismic anchor bolts.

2.4 FLEXIBLE PIPING CONNECTIONS

.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:

.1 nylon tire cord reinforced EPDM body;

.2 ductile iron reinforcing ring and ductile iron screwed or flanged connections as required and to suit piping system operating pressure.

2.5 VIBRATION ISOLATION PRODUCTS

.1 Refer to Section “20 05 48.13 - Vibration Controls for Mechanical Systems”.

3 Execution

3.1 INSTALLATION OF SEISMIC RESTRAINT MATERIALS

.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.

.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.

MECHANICAL COMPONENT RESTRAINT GUIDE

ITEM	**TYPE OF RESTRAINT**	**MINIMUM NO. OF RESTRAINTS**	**NOTES**
In-line Pumps Pumps Non-Isolated Pumps Isolated	SCR BTHP SNBR	2 4 4	Pipe mounted type pump Base mount type pump Base mount type pump
Expansion Tanks	SCR	4	
D.H.W. Tanks	SCR	4	Attach to removable steel strap yoke
Unit Heaters	TSR-SCR	4	
Force Flow Heaters	TSR-SCR	4	
AHU's and A/C Units Free Standing - With Base - Without base	 BTHP CSSB	 4 4	
AHU's and A/C Units Suspended - Isolated - Non-Isolated	 SCR SCR	 4 4	
Packaged Rooftop Air Units (all types) On roof curb	 BTRC	 4	 Roof curb bolted to roof.
Electronic Humidifiers		4	Bolt stand to housekeeping pad or structure.
Fans – Suspended - Isolated - Non-Isolated	 SCR SCR	 4 4	
Fans – Freestanding - Isolated - Non-Isolated	 SNBR BTHP	 4 4	
Grilles, Registers, Diffusers	SCR	4	Where not bolted to duct (i.e. in tee-bar ceilings)
Airflow Control Valves	SCR	4	Where suspended

ITEM	TYPE OF RESTRAINT	MINIMUM NO. OF RESTRAINTS	NOTES
Piping	SCR TSR	As required	As per Specification
Ductwork	SCR TSR	As required	As per Specification

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 Provide structural steel bases for equipment unless equipment manufacturer certifies direct attachment capabilities.

.4 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.

.5 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.

.6 Requirements pertaining to seismic control work are as follows:

- .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);
- .2 seismic control systems are to work in all directions;
- .3 fasteners and attachment points are to resist same maximum load as the seismic restraint;
- .4 drilled or power driven anchors and fasteners are not permitted;
- .5 no equipment, equipment supports or mounts are to fail before failure of structure;
- .6 supports of cast iron or threaded pipe are not permitted;
- .7 seismic control measures are not to interfere with integrity of firestopping;
- .8 equipment is to be bolted to structure, and bolts are to be fitted with isolation washers;
- .9 number, size, type, and installation of anchor bolts are to be as recommended by anchor bolt manufacturer and seismic design consultant;

.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;

.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;

.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;

.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;

.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;

.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.

.7 Provide slack cable restraint assemblies for:

.1 steam piping 32 mm (1-¼") dia. and larger;

.2 fuel gas, fuel oil, medical gas, compressed air and service piping 25 mm (1") dia. and larger;

.3 piping 32 mm (1-¼") dia. and larger located in boiler, fan, chiller, and similar equipment rooms;

.4 horizontal and vertical piping 65 mm (2-½") dia. and larger;

.5 ductwork and duct mounted equipment;

.6 isolated and non-isolated ceiling hung fans, tanks, equipment, etc.;

.7 generator exhaust system(s).

.8 Installation requirements for slack cable restraints include following:

.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;

.2 orient restraint wires on ceiling hung equipment at approximately 90º to each other (in plan), and tie back to the ceiling slab at an angle not exceeding 45º to slab;

.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;

.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;

.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;

.6 vary adjacent spacing of restraints on a piping run by 10% to 30% to avoid coincident resonance;

.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;

.8 provide flexibility in piping joints or sleeves where piping penetrates building seismic or expansion joints;

.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');

.10 install restraints at least 50 mm (2") clear of other equipment and services;

.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");

.12 provide transverse and axial restraints within 4 m (12') of a vertical bend;

.13 at steel trusses, connect to top chords at panel points and follow truss manufacturer's instructions;

.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;

.15 do not bridge vibration isolators with slack cable restraints;

.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

.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

.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 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 "Agency" – means agency to perform testing, adjusting and balancing work.

.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.

.3 "air systems" – includes outside air, supply air, return air, exhaust air, and relief air systems.

.4 "flow rate tolerance" – means allowable percentage variation, minus to plus, of actual flow rate values in Contract Documents.

.5 "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.

.6 "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.

.7 "main" – means duct or pipe containing system's major or entire fluid flow.

.8 "submain" – means duct or pipe containing part of the systems' capacity and serving 2 or more branch mains.

.9 "branch main" – means duct or pipe servicing 2 or more terminals.

.10 "branch" – means duct or pipe serving a single terminal.

1.3 SUBMITTALS

.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.

.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.

.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.

.4 Submit a report by Agency after each site visit made by Agency during construction phase of this Project.

.5 Submit a draft report, as specified in Part 3 of this Section.

.6 Submit a final report, as specified in Part 3 of this Section.

.7 Submit a testing and balancing warranty as specified in Part 3 of this Section.

.8 Submit reports listing observations and results of post construction site visits as specified in Part 3 of this Section.

1.4 QUALITY ASSURANCE

.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 AABC - Associated Air Balance Council;

.2 NEBB - National Environmental Balancing Bureau.

.2 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 National Standards for a Total System Balance published by Associated Air Balance Council;

.2 Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems published by National Environmental Balancing Bureau;

.3 Chapter 37, Testing, Adjusting, and Balancing of ASHRAE Handbook HVAC Applications.

2 Products – Not Used

3 Execution

3.1 SCOPE OF WORK

.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.

.2 Mechanical systems to be tested, adjusted and balanced include:

.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.

.2 TAB of air handling systems is to include equipment and ductwork air temperatures, capacities and flows.

3.2 TESTING, ADJUSTING, AND BALANCING

.1 Conform to following:

.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;

.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 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;

.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;

.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.

.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;

.7 obtain copies of reviewed shop drawings of applicable mechanical plant equipment and terminals, and temperature control diagrams and sequences;

.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;

.9 Agency is to check valves and dampers for correct and locked position, and temperature control systems for completeness of installation before starting equipment;

.10 wherever possible, Agency is to lock balancing devices in place at proper setting, and permanently mark settings on devices;

.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;

.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;

.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 excess of ±5% of design requirements, Agency is to report problem and issue a detail sketch of plenum baffle(s) required to eliminate stratification;

.14 Agency is to perform testing, adjusting and balancing to within ±5% of design values, and make and record measurements which are within ±2% of actual values;

.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;

.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.

.2 Prepare reports as indicated below.

.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.

.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 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 Temperature Control Systems;

.4 Special Systems.

.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 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 stop and Agency is to then rebalance systems involved, resubmit final report, and again perform spot checks with Contractor and Consultant.

.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.

.5 After acceptance of final report, Agency is to perform post testing and balancing site visits in accordance with following requirements:

.1 post testing and balancing site visits are to be made:

.1 once during first month of building operation;

.2 once during third month of building operation;

.3 once between fourth and tenth months in a season opposite to first and third month visit.

.2 during each return visit and accompanied by Owner’s representative, Agency is to spot rebalance terminal units as required to suit building occupants and eliminate complaints;

.3 Agency is to schedule each visit with Contractor and Owner, and inform Consultant;

.4 after each follow-up site visit, Agency is to issue to Contractor and Consultant a report indicating any corrective work performed during visit, abnormal conditions and complaints encountered, and recommended corrective action.

End of Section

1 General

1.1 APPLICATION

.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 "concealed" – means mechanical services and equipment above suspended ceilings, in non-accessible chases, in accessible pipe spaces, and furred-in spaces.

.2 "exposed" – means exposed to normal view during normal conditions and operations.

.3 "mineral fibre" – includes glass fibre, rock wool, and slag wool.

.4 "domestic water" or "potable water" – means piping extended from building Municipal supply main.

1.3 SUBMITTALS

.1 Submit a product data sheet for each insulation system product.

.2 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.

.3 Submit a colour chart for coloured lagging adhesive for canvas jacketed insulation.

1.4 QUALITY ASSURANCE

.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.

.2 Do not apply insulation unless leakage tests have been satisfactorily completed.

.3 Ensure surfaces to be insulated are clean and dry.

.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.

.5 Company with sub-contract for mechanical insulation work is to be a member in good standing of Thermal Insulation Association of Canada.

.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

.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

.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

.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 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. Acceptable products are:

.1 Armacell AP/Armaflex SS;

.2 IK Insulation Group K-Flex "LS" Self-Seal Pipe Insulation.

.3 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. Acceptable products are:

.1 Roxul "Techton 1200";

.2 IIG (Johns Manville Inc.) MinWool-1200;

.3 Paroc 1200.

.4 Pre-moulded mineral fibre is to be rigid, sectional, sleeve type insulation to ASTM C547, with a factory applied vapour barrier jacket. Acceptable products are:

.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.

.5 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. Acceptable products are:

.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.

2.4 BARRIER-FREE LAVATORY PIPING INSULATION KITS

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

.2 Acceptable products are:

.1 Truebo "Lav-Guard 2" E-Z Series;

.2 Zeston "SNAP-TRAP";

.3 McGuire Manufacturing Co. Inc. "ProWrap".

2.5 EQUIPMENT INSULATION MATERIALS

.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. Acceptable products are:

.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 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. Acceptable products are:

.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".

2.6 REMOVABLE/REUSABLE INSULATION COVERS

.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.

2.7 DUCTWORK SYSTEM INSULATION MATERIALS

.1 Rigid mineral fibre board is to be pre-formed board type insulation to ASTM C612, 48 kg/m3 (3 lb/ft^3) density, with a factory applied reinforced aluminum foil and kraft paper facing. Acceptable products are:

.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 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. Acceptable products are:

.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.

.3 Blanket mineral fibre is to be blanket type roll form insulation to ASTM C553, 24 kg/m3 (1½ lb/ft3) density, 40 mm (1-½") thick, with a factory applied vapour barrier facing. Acceptable products are:

.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.

.4 Pre-moulded calcium silicate is to be rigid block and sheet insulation. Acceptable products are:

.1 Johns Manville Inc. "Thermo-12 Gold";

.2 Industrial Insulation Group "Thermo-12 Gold".

.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. Acceptable products are:

.1 Armacell "AP/Armaflex SA";

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

2.8 INSULATING COATINGS

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

.1 anti-condensation coating, "No Sweat-FX";

.2 thermal insulating coating, "ThermaLite".

2.9 INSULATION FASTENINGS

.1 Wire – minimum #15 gauge galvanized annealed wire.

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

.3 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.

.4 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.

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

.6 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.

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

.8 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.

.9 Screws – No. 10 stainless steel sheet metal screws.

2.10 INSULATION JACKETS AND FINISHES

.1 Canvas Jacket Material – ULC listed and labelled, 25/50 fire/smoke rated, roll form, minimum 170 g (6 oz.).

.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. Acceptable products are:

.1 Proto Corp. "LoSMOKE";

.2 The Sure-Fit System "SMOKE-LESS 25/50";

.3 Johns Manville Inc. "Zeston" 300.

.3 Adhesive backed flexible aluminium is to be 3M "VentureClad 1577CW-E" roll form sheet material with an aggressive rubberized asphalt adhesive backing, high density polyethylene reinforcement, and an embossed aluminum facing.

.4 Flexible foam elastomeric insulation protective coating equal to Armacell "WB Armaflex" weatherproof, water-based latex enamel finish.

3 Execution

3.1 GENERAL INSULATION APPLICATION REQUIREMENTS

.1 Unless otherwise specified, do not insulate following:

.1 factory insulated equipment and piping;

.2 branch potable water piping located under counters to serve counter mounted plumbing fixtures and fittings, except barrier-free lavatories;

.3 exposed chrome plated potable water angle supplies from concealed piping to plumbing fixtures and fittings, except barrier-free lavatories;

.4 manufactured expansion joints and flexible connections;

.5 acoustically lined ductwork and/or equipment;

.6 factory insulated flexible branch ductwork;

.7 piping unions, except for unions in "cold" category piping.

.2 Install insulation directly over pipes and ducts, not over hangers and supports.

.3 Install piping insulation and jacket continuous through pipe openings and sleeves.

.4 Install duct insulation continuous through walls, partitions, and similar surfaces except at fire dampers.

.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.

.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.

.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.

.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.

.9 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.

.10 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.

.11 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

.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.

3.3 PIPE INSULATION REQUIREMENTS – MINERAL FIBRE

.1 Insulate following pipe inside building and above ground with mineral fibre insulation of thickness indicated:

.1 domestic cold water piping, less than 100 mm (4") dia. – 25 mm (1") thick;

.2 domestic cold water piping, greater than or equal to 100 mm (4") dia. – 40 mm (1-½") thick;

.3 domestic hot water piping, less than 40 mm (1-½") dia. – 25 mm (1") thick;

.4 domestic hot water piping, greater than or equal to 40 mm (1½") dia. – 40 mm (1-½") thick;

.5 tempered domestic water piping, supply and return, less than 40 mm (1-½") dia. – 25 mm (1") thick;

.6 tempered domestic water piping, supply and return, greater than or equal to 40 mm (1-½") dia. – 50 mm (2") thick;

.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;

.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;

.9 low pressure (to 140 kPa [20 psi]) steam piping, less than 100 mm (4") dia. – 65 mm (2-½") thick;

.10 low pressure condensate piping, less than 40 mm (1-½") dia. – 40 mm (2-½") thick;

.2 Secure overlap flap of the sectional insulation jacket tightly in place. Cover section to section butt joints with tape sealant.

.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.

.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.

.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.

.6 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.

.7 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.

3.4 PIPE INSULATION REQUIREMENTS – FLEXIBLE FOAM ELASTOMERIC

.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:

.1 refrigerant suction and hot gas piping inside and outside building – 25 mm (1") thick.

3.5 PIPE INSULATION REQUIREMENTS – FIRE RATED INSULATION

.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").

3.6 INSTALLATION OF BARRIER FREE LAVATORY INSULATION KITS

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

3.7 EQUIPMENT INSULATION REQUIREMENTS – BLANKET TYPE MINERAL FIBRE

.1 Insulate following equipment with mineral fibre blanket type insulation of thickness indicated:

.1 roof drain sumps where inside the building – 25 mm (1") thick;

.2 water meter(s) – 40 mm (1-½") thick;

.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 Cover roof drain sumps with purpose made PVC fitting covers.

.4 Lay fibreglass blanket on radiant ceiling panels after testing is complete.

3.8 EQUIPMENT INSULATION REQUIREMENTS – SEMI-RIGID MINERAL FIBRE

.1 Insulate following equipment with semi-rigid mineral fibre board insulation of thickness indicated:

.1 uninsulated domestic hot water storage tank(s) – 40 mm (1-½") thick;

.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 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.

3.9 DUCTWORK INSULATION REQUIREMENTS – MINERAL FIBRE

.1 Insulate following ductwork systems inside building and above ground with mineral fibre insulation of thickness indicated:

.1 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;

.2 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 any other ductwork, casings, plenums or sections specified or detailed on drawings to be insulated – thickness as specified.

.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 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:

.1 at trapeze hanger locations, install insulation between duct and hanger;

.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.

.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.

.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.

.6 Insulation application requirements common to all types of rigid ductwork are as follows:

.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;

.2 installation of fastener pins and washers is to be concurrent with duct insulation application;

.3 cut insulation fastener pins almost flush to washer and cover with neatly cut pieces of tape sealant;

.4 accurately and neatly cut and fit insulation at duct accessories such as damper operators (with standoff mounting) and pitot tube access covers;

.5 prior to concealment of insulation by either construction finishes or canvas jacket material, patch vapour barrier damage by means of tape sealant.

3.10 DUCTWORK INSULATION REQUIREMENTS – FLEXIBLE ELASTOMERIC

.1 Insulate exposed exterior ductwork (except fresh air intake ductwork) and associated plenums and/or casings outside building with minimum 40 mm (1-½") thick flexible elastomeric sheet insulation as required, applied in 2 minimum 20 mm (¾") thick layers with staggered tightly butted joints.

.2 Insulate following ductwork systems inside building and above ground with flexible elastomeric insulation of thickness indicated:

.1 outside 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;

.2 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 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.

3.11 DUCTWORK INSULATION REQUIREMENTS – CALCIUM SILICATE

.1 Insulate following kitchen exhaust ductwork with minimum 40 mm (1-½") thick calcium silicate block insulation:

.1 kitchen exhaust ductwork from exhaust hood to masonry shaft – 2 hour rating;

.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.

3.12 APPLICATION OF INSULATING COATINGS

.1 Apply, in accordance with manufacturer’s instruction, insulating coatings to following bare metal surfaces:

.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;

.2 paint bare metal surfaces associated with mechanical systems with an operating temperature 60°C (140°F) with "ThermaLite" insulating coating.

.2 Apply coatings with a brush. Remove any splatter or excess coating from adjacent surfaces.

3.13 INSULATION FINISH REQUIREMENTS

.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.

.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.

.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.

.4 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 all exterior insulation.

.5 Apply 2 coats (with 24 hr. between coats) of specified coating to flexible elastomeric insulation outside building and cover with adhesive backed flexible aluminum.

End of Section

1 General

1.1 SUBMITTALS

.1 Submit shop drawings/product data sheets to regulatory authority for review and approval prior to submitting to Consultant. Conform to following requirements:

.1 submit shop drawings/product data sheets for all products specified in this Section except pipe and fittings;

.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;

.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;

.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;

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

1.2 QUALITY ASSURANCE

.1 Fire protection sprinkler system work is to be in accordance with following Codes and Standards:

.1 NFPA 13, Standard for the Installation of Sprinkler Systems;

.2 CSA B137.2, Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications;

.3 CSA B137.3, Rigid Polyvinylchloride (PVC) Pipe for Pressure Applications;

.4 ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless;

.5 ASTM A135, Standard Specification for Electric-Resistance-Welded Steel Pipe;

.6 ASTM A234, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service;

.7 ASTM A536, Standard Specification for Ductile Castings;

.8 ASTM A795, Standard Specification for Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use;

.9 ANSI/ASME B16.4, Grey Iron Threaded Fittings (Classes 125 and 250);

.10 CAN/CSA B64.10, Backflow Preventers and Vacuum Breakers.

.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.

.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.

.4 System components must be ULC listed and labelled.

.5 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.

.6 All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.3 DESIGN REQUIREMENTS

.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.

.2 Include for a qualified mechanical professional engineer registered and licensed in the jurisdiction of the work to design the fire protection standpipe work. Refer to Section 20 05 10 – Mechanical Work General Instructions for requirements regarding Contractor retained engineers.

.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

.1 Pipe, fittings and joints are to be as follows, with exceptions as specified in Part 3 of this Section:

.1 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 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.

.3 Schedule 10 Steel – Grooved Coupling Joints

.1 Schedule 10 mild black carbon steel, ASTM A53, Grade B, complete with grooved ends and fitings and couplings equal to Victaulic "FireLock" fittings and Victaulic Style 009N, 107H, and 107N QuickVic and 005 rigid coupling joints.

.4 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.

.5 "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.

.6 "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.

.7 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:

.1 (4) bends at 31" length;

.2 (5) bends at 36" length;

.3 (8) bends at 48" length;

.4 (10) bends at 60" length;

.5 (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 ½ or ¾" 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.

.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.

.8 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

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 ASSEMBLY

.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 Acceptable manufacturers are:

.1 Watts Industries Canada;

.2 Zurn/Wilkins;

.3 Apollo Valves (Conbraco Industries).

2.3 SHUT-OFF VALVES

.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 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.

.3 Standard of Acceptance: Victaulic Style 705.

.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).

.5 Supervised closed applications standard of acceptance Victaulic Series 707C supervised closed butterfly valve.

2.4 CHECK VALVES

.1 Minimum 1725 kPa (250 psi) resilient seat check valves, suitable for vertical or horizontal installations. Standard of Acceptance: Victaulic Series 717.

.2 Check valves associated with Fire Department connections and fire pump test connection are to be tapped for site installation of a 20 mm (¾") diameter ball drip.

2.5 BALL DRIPS

.1 Equal to National Fire Equipment Ltd. Model #A58, 20 mm (¾") diameter automatic ball drip.

2.6 SHUT-OFF VALVE SUPERVISORY SWITCHES

.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 Actuator housings shall be weatherproof.

2.7 FIRE DEPARTMENT CONNECTION

.1 Wall mounting polished brass clapper type dual inlet Fire Department connection with 2, 65 mm (2-½") diameter inlets threaded to Fire Department hose requirements and equipped with caps and chains, an outlet sized as shown, and a faceplate.

.2 Faceplate is to be polished brass and complete with "AUTO-SPKR" cast-in raised lettering.

.3 Exposed metal parts of Fire Department connection are to be chrome plated.

.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. Standard of Acceptance: Victaulic #10-DR.

2.8 WATER FLOW ALARM SWITCH

.1 Pipe mounting water flow alarm switch, minimum 1725 kPa (250 psi) rated, designed to actuate 2, 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 rest 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.

2.9 ALARM CHECK VALVE

.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:

.1 pipe, fittings and accessories for site connection of an excess pressure pump;

.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;

.3 alarm test by-pass piping with ball valve to permit alarm testing without operation of alarm valve;

.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.

2.10 EXCESS PRESSURE PUMP

.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:

.1 stainless steel shaft with maintenance free seal;

.2 lifetime lubricated carbon bearings;

.3 TEFC motor conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, and secured to a mounting base;

.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;

.5 power and control panel.

.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:

.1 door interlock fused disconnect with HRC fuses;

.2 protected type pump starter;

.3 door mounted H-O-A rotary selector switch;

.4 fused control transformer;

.5 115 volt adjustable pressure switch to suit the application;

.6 set of NO/NC dry contacts for connection of lack of power availability alarm;

.7 door mounted "POWER ON" LED.

2.11 SPRINKLER HEADS

.1 Sprinkler heads, unless otherwise specified, are to be as scheduled in Part 3 of this Section.

.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.

.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).

.4 Sprinkler heads for healthcare facilities are to be quick response type.

.5 Recessed sprinkler heads in finished areas are to be chrome plated unless otherwise specified. Concealed sprinkler head ceiling plates are to match ceiling colour.

.6 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.

.7 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.

.8 Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

.9 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.

.10 Acceptable manufacturers are:

.1 Victaulic Co.;

.2 Tyco Fire Suppression & Building Products;

.3 The Viking Corporation;

.4 The Reliable Automatic Sprinkler Co.

2.12 SPARE SPRINKLER HEAD CABINET

.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 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.

3 Execution

3.1 PIPING INSTALLATION REQUIREMENTS

.1 Provide required sprinkler system piping.

.2 Perform piping work in accordance with requirements of NFPA 13, governing regulations, and "Reviewed" shop drawings.

.3 Piping, unless otherwise specified, is as follows:

.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;

.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 for wet system piping inside building and above ground – at your option, CPVC sprinkler pipe and fittings;

.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;

.5 for branch piping to heads in suspended ceilings, etc. – at your option, flexible piping installed in accordance with manufacturer’s instructions;

.6 for branch piping to heads in MRI suites – copper pipe, fittings, and sprinkler head adapters with stainless steel hangers and support hardware.

.4 Exceptions to piping requirements specified above are as follows:

.1 dry pipe zone steel piping, fittings, unions, couplings and flanges are to be galvanized;

.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 PVC piping is not to be used above grade;

.4 ferrous pipe hangers, supports, and similar hardware used for galvanized steel piping are to be electro-galvanized.

.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.

.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.

.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.

.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.

.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 installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products.

3.2 INSTALLATION OF DOUBLE CHECK VALVE ASSEMBLY

.1 Provide a double check valve assembly in sprinkler main inside the building.

.2 Equip assembly with inlet and outlet shut-off valves with supervisory switches as specified below.

.3 Support each end of assembly from floor by means of flanged pipe supports with saddles.

3.3 INSTALLATION OF SHUT-OFF VALVES AND CHECK VALVES

.1 Provide shut-off valves and check valves in piping where shown and wherever else required.

.2 Locate valves for easy operation and maintenance.

.3 Confirm exact locations prior to roughing-in.

3.4 INSTALLATION OF SHUT-OFF VALVE SUPERVISORY SWITCHES

.1 Equip each shut-off valve with a supervisory switch.

.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.

3.5 INSTALLATION OF FIRE DEPARTMENT CONNECTION

.1 Provide an exterior Fire Department connection. Confirm exact location prior to roughing-in. Confirm finish prior to ordering.

.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.

3.6 INSTALLATION OF FLOW ALARM SWITCHES

.1 Provide water flow alarm switches in accessible locations in zone piping.

.2 Adjust to suit site water pressure conditions. Check and test operation.

.3 Identify each switch with a 150 mm (6") square red-white laminated engraved plastic tag. Confirm wording prior to engraving.

3.7 INSTALLATION OF ALARM CHECK VALVES

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

.2 Check and test operation of each valve and adjust as required to suit site water pressure conditions.

.3 Identify each valve with a 150 mm (6") square red-white laminated engraved plastic tag. Confirm wording prior to engraving.

3.8 INSTALLATION OF EXCESS PRESSURE PUMP AND CONTROL

.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.

.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 Start-up the pump, test operation and adjust as required.

3.9 INSTALLATION OF SPRINKLER HEADS

.1 Provide required sprinkler heads in accordance with following schedule:

APPLICATION	SPRINKLER HEAD TYPE
Rooms/areas with a suspended ceiling	Victaulic V38/V39 or Tyco Series RFII "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 service spaces and SCBA Scuba room.	Victaulic V36 or Tyco Series DS-1 dry pipe horizontal sidewall Victaulic V36 or Tyco Series DS-3 wet pipe horizontal sidewall
Heated apparatus bay	Victaulic V34 or Tyco Series EC-11 or EC-14 ECOH upright or Victaulic V27 or Series TY-FRB upright for wet piping

.2 Sprinkler head manufacturers indicated on schedule are for type indication purposes. Acceptable manufacturers are listed in Part 2 of this Section.

.3 Provide quick response type sprinkler heads.

.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.

.5 Maintain maximum headroom in areas with no ceilings.

.6 Provide guards for heads where they are subject to damage.

.7 Provide high temperature heads in equipment rooms and similar areas over heat producing or generating equipment.

3.10 INSTALLATION OF SPARE SPRINKLER HEAD CABINET

.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.

End of Section

1 General

1.1 SUBMITTALS

.1 Submit product data sheets for all products specified in this Section.

1.2 QUALITY ASSURANCE

.1 Fire extinguishers are to be in accordance with following Codes and Standards:

- .1 National Fire Code of Canada;
- .2 NFPA 10, Standard for Portable Fire Extinguishers;
- .3 CAN/ULC S508, Standard for the Rating and Testing of Fire Extinguishers.

2 Products

2.1 GENERAL

.1 Fire extinguishers are to be pressurized (stored pressure) rechargeable type, in accordance with NFPA 10, and UL and/or ULC listed and labelled for the class of fires and hazard locations for which they are specified.

.2 Each extinguisher is to be complete with:

- .1 manufacturer’s identification label indicating extinguisher model number, rating, and operating instructions;
- .2 anodized aluminum or chrome plated forged brass valve with positive squeeze grip on-off operation and a pull-pin safety lock;
- .3 discharge hose with nozzle or horn and hose securing clip;
- .4 for wall mounting extinguishers, a wall mounting bracket.

2.2 3A10B:C RATED DRY CHEMICAL EXTINGUISHERS

.1 Multi-purpose 3A10B:C dry chemical extinguishers are to be 100 mm (4") dia., 2.27 kg (5 lb.), each complete with a steel cylinder with a safety red baked enamel finish and a waterproof stainless steel pressure gauge.

2.3 FIRE EXTINGUISHER CABINETS

.1 Recessed: Rectangular cabinets sized to suit the extinguishers to be housed, with a #18 gauge corrosion resistant white enamelled steel tub, #14 gauge cleaned and prime coat painted steel door and adjustable trim assembly with rounded corners, semi-concealed piano hinge, safety glass panel, and flush stainless steel door latch.

2.4 FIRE BLANKETS

.1 Equal to National Fire Equipment Ltd. Model #FB-6078-MC 300 mm x 400 mm (12" x 16") red enamelled #16 gauge surface mounting steel cabinet identified "FIRE BLANKET" and "PULL TAB TO REMOVE", complete with non-combustible glass fibre fire blanket pressure fit into the cabinet and equipped with pull-back release straps.

3 Execution

3.1 INSTALLATION OF FIRE EXTINGUISHERS

.1 Provide fire extinguishers of type(s) in accordance with requirements of NFPA 10.

.2 Unless otherwise shown or specified, wall mount extinguishers using wall brackets supplied with extinguishers.

.3 Do not install extinguishers until after wall finishing work is complete.

.4 Be responsible for maintaining fire extinguishers until Substantial Completion of the Work.

.5 If extinguishers are indicated adjacent to a door, locate extinguishers at the strike side of the door.

3.2 INSTALLATION OF FIRE EXTINGUISHER CABINETS

.1 Provide wall cabinets for fire extinguishers where required.

.2 Unless otherwise shown or specified, locate cabinets so centerline is approximately 1.2 m (4') above finished floor.

.3 Confirm exact locations prior to installation.

3.3 INSTALLATION OF FIRE BLANKETS

.1 Provide fire blankets in wall mounted cabinets in the Kitchen. Confirm exact locations prior to installation.

End of Section

1 General

1.1 SUBMITTALS

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

1.2 CLOSEOUT SUBMITTALS

.1 Submit laboratory water purity test results indicating chlorine residual prior to application for Substantial Performance of the Work.

.2 Prior Substantial Performance of the Work, submit a minimum of 3 identified keys for key operated hydrants.

.3 Submit signed test results and inspection and test log cards for each backflow preventer as specified in Part 3 of this Section.

.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.

.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.

1.3 QUALITY ASSURANCE

.1 Domestic water piping and valves are to comply with following codes, regulations and standards (as applicable):

.1 applicable local codes and regulations;

.2 CAN/CSA B125.1, Plumbing Supply Fittings;

.3 CAN/CSA B125.3, Plumbing Fittings;

.4 CAN/CSA B137 Series, Thermoplastic Pressure Piping Compendium;

.5 NSF/ANSI 14, Plastics Piping System Components and Related Materials;

.6 NSF/ANSI 61, Drinking Water System Components – Health Effects;

.7 NSF/ANSI 372, Drinking Water System Components – Lead Content.

2 Products

2.1 PIPE, FITTINGS, AND JOINTS

.1 PVC

.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 Soft Copper

.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.

.3 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 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.

.4 Copper - Grooved

.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.

.5 Semi-Rigid Polyethylene Tubing

.1 Versa Fittings and Mfg. Inc. 12 mm (½") dia., high density, semi-rigid polyethylene tubing, 1380 kPa (200 psi) rated.

.6 CPVC

.1 Ipex "Aquarise" CPVC pipe and fittings to CAN/CSA B137.6, 25/50 flame spread and smoke developed rated in accordance with CAN/ULC S102.2, and complete with primer/solvent weld joints.

.2 Option: Fittings equal to Victaulic PGS-300 grooved piping system for schedule 40 and schedule 80 CPVC pipe per ASTM F441, 23447 minimum cell classification per ASTM D1784. Sizes 50-300 mm (2" - 12") consisting of ductile iron cast housings, complete with a grade "EHP" EPDM gasket of a pressure-responsive design, with plated nuts and bolts to secure unit together (Viictaulic Style 357).

.7 Cross-Linked Polyethylene (PEX) Tubing

.1 Non-barrier type PEX-A 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

.1 Ball Valves

.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, solid forged brass chrome plated ball, "Teflon" or "PTFE" seat, and a removable lever handle. Valves in insulated piping are to be complete with stem extensions.

.2 Acceptable products are:

.1 Toyo Valve Co. Fig. 5049A-LF;

.2 Milwaukee Valve Co. #UPBA485B;

.3 Kitz Corporation Code 859;

.4 Apollo Valves #77LF-200;

.5 Watts Industries (Canada) Inc. #LFFBVS-3C.

2.3 CHECK VALVES

.1 Horizontal

.1 Lead-free, Class 125, bronze, 1380 kPa (200 psi) WOG rated horizontal swing type check valves with solder ends.

.2 Acceptable products are:

.1 Toyo Valve Co. Fig. 237A-LF;

.2 Milwaukee Valve Co. #UP1509;

.3 Kitz Corporation Code 823;

.4 Apollo Valves #61LF Series.

.2 Vertical

.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

.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.

.2 Acceptable products are:

- .1 Toyo Valve Co. Fig. 5046;
- .2 Dahl Brothers Canada Ltd. Fig. No. 50. 430;
- .3 Kitz Corporation Code 58CC;
- .4 Apollo Valves #78-104-01;
- .5 Watts Industries (Canada) Inc. #B6000.

2.5 DOMESTIC WATER PIPING BALANCING VALVES

.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 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 CHLORINE

.1 Sodium hypochlorite to AWWA B300.

2.7 INTERIOR HOSE BIBBS

.1 Flush-Concealed

- .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 Acceptable products are:
  - .1 Watts Industries (Canada) Inc. #HY-330.
  - .2 Jay R. Smith #5509QT-CL-SAP;
  - .3 Zurn #Z1350;
  - .4 Mifab #MHY-55;

.2 Semi-Recessed - Finished Areas

- .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 Acceptable products are:
  - .1 Watts Industries (Canada) Inc. #HY-430.
  - .2 Jay R. Smith #5619-SAP-98;
  - .3 Zurn #Z1333 "ECOLOTROL";
  - .4 Mifab #MHY-30;

.3 Surface – Exposed – Cold Water – Unfinished Areas

- .1 Brass or bronze hose bibb with hose end vacuum breaker.

.2 Acceptable products are:

.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;

2.8 EXTERIOR NON-FREEZE WALL HYDRANTS

.1 Flush-Concealed

.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 (¾") dia. threaded hose connection outlet, vacuum breaker, and a loose tee handle operating key.

.2 Acceptable products are:

.1 Watts Industries (Canada) Inc. #HY-725.

.2 Jay R. Smith #5519-98;

.3 Zurn #Z1320;

.4 Mifab #MHY-26;

2.9 FLOOR DRAIN TRAP SEAL PRIMERS

.1 Electronic Type

.1 Precision Plumbing Products #MPB Series surface wall mounting, CSA certified, 115 volt, 1-phase, 60 Hz., electronic, automatic trap priming manifolds, each sized to suit up to four drain traps or interceptors serviced, and each complete with:

.1 galvanized steel cabinet with door;

.2 13 mm (1/2") dia. NPT copper pipe inlet with shut-off valve and water hammer arrestor;

.3 solenoid valve, air gap, and for priming 2-4 traps from a single primer, a Model DU-2, DU-3, or DU-4, 2, 3 or 4 outlet distribution unit for priming 2, 3 or 4 traps to suit the number of items to be primed;

.4 control panel with circuit breaker, 2 ampere circuit breaker, 24 hour timer, and manual override toggle switch

.2 Precision Plumbing Products #PT Series surface wall mounting, CSA certified, 115 volt, 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 ampere fuse, 24 hour timer, and manual override toggle switch.

2.10 SHOCK ABSORBERS

.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 potable water pipe and equipment it is provided for.

.2 Acceptable products are:

.1 Watts Industries (Canada) Inc. "SG" Series.

.2 Jay R. Smith 5000 Series "HYDROTROL";

.3 Zurn #Z1700 "SHOKTROL";

.4 Mifab "HAMMERGUARD" WHB Series;

2.11 WATER HAMMER ARRESTORS

.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 Acceptable products are:

.1 Jay R. Smith 5000 Series;

.2 Precision Plumbing Products "SS" Series.

2.12 BACKFLOW PREVENTERS

.1 Double Check Valve Assembly

.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 Acceptable manufacturers are:

.1 Watts Industries Canada;

.2 Zurn/Wilkins;

.3 Apollo Valves (Conbraco Industries).

.2 Reduced Pressure Zone Assembly

.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 Acceptable products are:

.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.

2.13 LAVATORY SUPPLY FITTING TEMPERING VALVES

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

2.14 AIR VENTS

.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.

2.15 DOMESTIC WATER THERMAL EXPANSION TANK

.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 Acceptable products are:

.1 Watts Industries (Canada) Inc. Series DETA;

.2 Zurn/Wilkins Model WTTA.

3 Execution

3.1 PIPING INSTALLATION REQUIREMENTS

.1 Provide required domestic water piping.

.2 Piping, unless otherwise specified, is as follows:

.1 for underground piping 100 mm (4") dia. and larger outside and/or inside the building – rigid PVC;

.2 for underground piping less than 100 mm (4") dia. inside building – Type "K" soft copper;

.3 for 12 mm (½") dia. trap seal primer tubing located underground or in concrete or masonry construction – semi-rigid polyethylene;

.1 for pipe inside building and aboveground in sizes to 100 mm (4") dia. – Type "L" hard copper with solder joints.

.3 pipe for defects before being lowered into trench.

.4 Slope piping so it can be completely drained.

.5 Provide cast brass dielectric type adapters/unions at connections between ferrous and copper pipe or equipment.

3.2 INSTALLATION OF SHUT-OFF AND CHECK VALVES

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

.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.

3.3 INSTALLATION OF DRAIN VALVES

.1 Provide a drain valve at the bottom of domestic water piping risers, at other piping low points, and wherever else shown.

.2 Locate drain valves so they are easily accessible.

3.4 INSTALLATION OF DOMESTIC WATER PIPING BALANCING VALVES

.1 Provide balancing valves in each domestic hot water recirculation piping connection to the domestic hot water supply and as shown:

.1 for pipe 19 mm (3/4”) dia. and less ground – equal to Victaulic Series 76X

.2 for pipe greater than 19 mm (3/4”) dia. – equal to Victaulic TA Series 78BL

.2 Locate each valve so it is easily accessible.

3.5 INSTALLATION OF HOSE BIBBS

.1 Provide hose bibbs.

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

3.6 INSTALLATION OF EXTERIOR NON-FREEZE WALL HYDRANTS

.1 Provide non-freeze wall hydrants.

.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 Provide a shut-off valve inside building to each exterior non-freeze wall hydrant.

3.7 INSTALLATION OF TRAP SEAL PRIMERS

.1 Provide required accessible trap seal primers to automatically maintain a water seal in floor drain traps, whether shown on drawings or not.

.2 Provide 115 volt, electronic, surface wall mounting trap primer assemblies for 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 Ensure trap primer piping is secured to floor drain primer tappings and not terminated through the tapping in the throat of the drain.

3.8 INSTALLATION OF SHOCK ABSORBERS

.1 Provide accessible shock absorbers in domestic water piping.

.2 Ensure size of each shock absorber is properly selected to suit size of domestic water pipe and equipment pipe is connected to.

3.9 INSTALLATION OF WATER HAMMER ARRESTORS

.1 Provide accessible water hammer arrestors in domestic water piping in locations as follows:

- .1 in headers at groups of plumbing fixtures;
- .2 at top of risers;
- .3 at ends of long horizontal runs of piping;
- .4 in piping connecting solenoid valves or equipment with integral solenoid valves;
- .5 wherever else shown or required by Code.

.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.

3.10 INSTALLATION OF BACKFLOW PREVENTERS

.1 Provide a reduced pressure zone assembly backflow preventer in each direct domestic water connection to equipment other than plumbing fixtures and fittings and at all interior hose-bibs.

.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 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. Equip each backflow preventer with an air gap fitting and pipe the reduced pressure zone water outlet to drain.

.4 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.

3.11 INSTALLATION OF LAVATORY SUPPLY FITTING TEMPERING VALVES

.1 Provide thermostatic water tempering valves for hot water supply to public washroom lavatory supply fittings. Conceal valves and piping.

.2 Provide a flush wall mount panel for each valve. Confirm exact location prior to roughing-in.

.3 Install in accordance with manufacturer's instructions and set mixing valves to deliver 32°C (90°F) tempered water.

3.12 INSTALLATION OF AIR VENTS

.1 Provide accessible air vents in domestic water piping to prevent air binding.

.2 Extend copper indirect drain piping from top drain connection of each vent to nearest suitable drain.

.3 Locate exact vent locations on as-built record drawings.

3.13 INSTALLATION OF DOMESTIC WATER THERMAL EXPANSION TANK

.1 Provide domestic water thermal expansion tanks.

.2 Unless otherwise specified, mount at least 450 mm (18") from cold water inlet to domestic water heater.

.3 Adjust pre-charge to match incoming water pressure after installation.

.4 Install in accordance with manufacturer's instructions and as per local governing Codes and Regulations.

3.14 FLUSHING AND DISINFECTING PIPING

.1 Flush and disinfect all new and/or reworked domestic water piping after leakage testing is complete.

.2 Isolate new piping from existing piping prior to flushing and disinfecting procedures.

.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.

.4 When flushing is complete, disinfect the piping with a solution of chlorine in accordance with AWWA C601.

.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 SUBMITTALS

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

.2 Submit manufacturer/supplier installation certification letters as specified in Part 3 of this Section.

.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 HORIZONTAL IN-LINE CIRCULATING PUMPS

.1 All bronze construction centrifugal pumps in accordance with drawing schedule and complete with:

- .1 lead free cast bronze casing with flanged pipe connections;
- .2 alloy steel shaft with integral thrust collar, copper shaft sleeve, and oil lubricated bronze sleeve bearings;
- .3 balanced lead free cast bronze impeller;
- .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;
- .5 mechanical seal.

.2 Acceptable manufactures are:

- .1 S.A. Armstrong Ltd.;
- .2 ITT Bell & Gossett;
- .3 Grundfos Canada Inc.;
- .4 Patterson Pump Company.

2.2 CIRCULATING PUMP AUTOMATIC CONTROLS

.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 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 CIRCULATING PUMPS

.1 Provide horizontal in-line domestic hot water circulating pumps.

.2 Install pumps in place in vertical piping approximately 1.2 m (4') above floor in accordance with pump manufacturer’s instructions.

.3 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.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 CIRCULATING PUMP CONTROLS

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

1.2 CLOSEOUT SUBMITTALS

.1 Submit a copy of plumbing inspection certificate prior to application for Substantial Performance of the Work.

.2 Submit letters from product manufacturers/suppliers to certify correct installation of products as specified in Part 3 of this section.

2 Products

2.1 PIPE, FITTINGS, AND JOINTS

.1 PVC Sewer

.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 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 PVC - DWV

.1 Equal to Ipex System XFR 15-50 rigid PVC drain, waste and vent pipe and fittings to CAN/CSA B181.2, complete with a flame spread rating less than 25 and a smoke developed rating less than 50 when tested to CAN/ULC S102.2, solvent weld joints, and, for fire barrier penetration, approved firestop conforming to CAN/ULC S115.

.3 Copper - Solder Joint

.1 Type DWV hard temper to ASTM B306, with forged copper solder type drainage fittings and 50% lead - 50% tin solder joints.

.4 Cast Iron

.1 Class 4000 cast iron pipe, fittings, and mechanical coupling joints to CAN/CSA B70.

.5 Copper-Victaulic Coupling Joint

.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.

2.2 VENT STACK COVERS

.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 CLEANOUTS

.1 Horizontal Piping

.1 TY pipe fitting with an extra heavy brass plug screwed into the fitting.

.2 Vertical Piping

.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.

.3 Urinal(s)

.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 Acceptable products are:

.1 Watts Industries (Canada) Ltd. #CO-590-RD.

.2 Jay R. Smith #SQ4-1819;

.3 Zurn #ZSS-1666-1;

.4 Mifab #C1440-RD;

2.4 FLOOR CLEANOUT TERMINATIONS

.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 Acceptable products are:

.1 Watts Industries (Canada) Ltd. # CO-200-R-1.

.2 Jay R. Smith #4020-F-C Series;

.3 Zurn # ZN-1602-SP Series;

.4 Mifab # C1100-XR-1 or #C1000-R-3;

.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.

2.5 FLOOR DRAINS, FUNNEL FLOOR DRAINS, AND HUB DRAINS

.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 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.

.3 Acceptable manufacturers are:

.1 Watts Industries (Canada) Ltd.;

.2 Jay R. Smith Manufacturing Co.;

.3 Zurn Industries Ltd.;

.4 Mifab Inc.

2.6 ROOF DRAINS

.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 Acceptable manufacturers are:

.1 Watts Industries (Canada) Ltd.;

.2 Jay R. Smith Manufacturing Co.;

.3 Zurn Industries Ltd.;

.4 Mifab Inc.

2.7 DRAINAGE TRENCH FRAMES AND GRATING

.1 Welded, hot dipped galvanized, 45 mm x 45 mm x 6.4 mm (1-¾" x 1-¾" x ¼") carbon steel angle frame, 300 mm (12") wide, with anchor straps and lengths as required, and baked epoxy coated cast iron slotted grating in 600 mm (24") long sections.

.2 Acceptable products are:

.1 Watts Industries (Canada) Ltd. #TD-910-B1-4;

.2 Jay R. Smith #2971VP.

.3 Zurn # Z796VP;

2.8 TRENCH DRAINS

.1 Modular, pre-sloped, ductile iron frame, UV stabilized talc-filled polypropylene construction interlocking sections of drainage channel with overlapping joints, 6" wide, 6x24x24 catch basin with trash basket, end caps and covers to suit the application, integral anchor tabs for grate anchoring and trench levelling, heavy-duty coated steel angle top frames, and heavy-duty ADA coated cast iron slotted grate supplied in 600 mm (24") long sections rated for minimum DIN Class E.

.2 Acceptable products are:

.1 Watts Industries (Canada) Inc. "Dead Level D" Series;

.2 Jay. R. Smith #9931 Series.

.3 Zurn "Z886-HDG" System;

2.9 TRENCH DRAINS

.1 Modular, pre-sloped, ductile iron frame, UV stabilized talc-filled polypropylene construction interlocking sections of drainage channel with overlapping joints, 6" wide, 6x24x24 catch basin with trash basket, end caps and covers to suit the application, integral anchor tabs for grate anchoring and trench levelling, heavy-duty coated steel angle top frames, and heavy-duty ADA coated cast iron slotted grate supplied in 600 mm (24") long sections rated for minimum DIN Class E.

.2 Acceptable products are:

.1 Watts Industries (Canada) Inc. "Dead Level D" Series;

.2 Jay. R. Smith #9931 Series.

.3 Zurn "Z886-HDG" System;

2.10 OIL INTERCEPTORS

.1 Epoxy coated steel construction automatic oil interceptor rated for 100 GPM with removable baffles, deep seal trap with cleanout, sediment bucket, heavy duty load rated cover, flow control fitting, 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 Acceptable products are:

.1 Mifab MI-O Series;

.2 Watts Industries (Canada) Inc.;

.3 Jay R. Smith.

.4 Zurn ;

2.11 LINT TROUGHS

.1 Type 304 stainless steel, 12’ long lint trough with removable stainless steel filter screens, perforated stainless steel dome bottom strainer, and 4"(102) no hub bottom outlet.

.2 Acceptable products are:

.1 Watts LI-LT;

.2 Jay. R. Smith SQ-9-3615 Series;

3 Execution

3.1 DRAIN AND VENT PIPING INSTALLATION REQUIREMENTS

.1 Provide required drainage and vent piping. Pipe, unless otherwise specified, as follows:

.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.;

.2 for pipe inside building and aboveground in sizes less than or equal to 65 mm (2-½") dia. – type DWV copper;

.3 for pipe inside building and aboveground in sizes greater than or equal to 75 mm (3") dia. – Class 4000 cast iron;

.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;

.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 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.

.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').

.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.

.6 Provide cast brass dielectric unions at connections between copper pipe and ferrous pipe or equipment.

3.2 INSTALLATION OF SHUT-OFF AND CHECK VALVES

.1 Provide a shut-off valve and a check valve in discharge piping of each drainage pump.

.2 Locate valves so they are easily accessible without the use of ladders or other such devices.

3.3 SUPPLY OF VENT STACK COVERS

.1 Supply a properly sized vent stack cover for each vent stack penetrating roof.

.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.

3.4 INSTALLATION OF CLEANOUTS

.1 Provide cleanouts in drainage piping in locations as follows:

.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;

.2 at or as close as practicable to the foot of each drainage stack;

.3 at maximum 15 m (50') intervals in horizontal pipe 100 mm (4") dia. and smaller;

.4 at maximum 30 m (100') intervals in horizontal pipe larger than 100 mm (4") dia.;

.5 in the wall at each new urinal or bank of urinals in a washroom;

.6 wherever else shown on drawings.

.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 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.

3.5 INSTALLATION OF FLOOR CLEANOUT TERMINATIONS

.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.

.2 In waterproof floors, ensure each cleanout termination is equipped with a flashing clamp device. Cleanout terminations are to suit floor finish.

.3 Where cleanout terminations occur in finished areas, confirm locations prior to rough-in and arrange piping to suit.

.4 Ensure cleanout termination covers in tiled floor are square in lieu of round.

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

.1 Provide floor drains, funnel floor drains and hub drains.

.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 Equip each drain with a trap.

.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.

.5 Confirm exact location of drains prior to roughing in. Where floor drains occur in washrooms coordinate locations with toilet partition installations.

.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.

3.7 INSTALLATION OF ROOF DRAINS

.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.

.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.

3.8 INSTALLATION OF DRAINAGE TRENCH FRAMES AND GRATING

.1 Supply frame and grating sections for drainage trench. Provide piping connections, traps, etc., as required.

.2 Hand frames to concrete trade forming and pouring trenches. Ensure frames are properly and accurately installed.

.3 Be present during concrete pour to ensure frames are not dislodged or damaged and remain straight and true. Immediately report any problems.

.4 Install grates and secure in place. Temporarily cover grates during construction procedures. Clean trenches when work is complete.

3.9 INSTALLATION OF TRENCH DRAINS

.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.

.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 Install grating and secure in place.

.4 Temporarily cover trench drainage openings during construction procedures. Clean trenches when work is complete.

3.10 INSTALLATION OF DRAINAGE INTERCEPTOR

.1 Provide an interceptor in drainage piping.

.2 Ensure unit is easily accessible for maintenance. Confirm exact location prior to roughing-in.

.3 Wall mount control panel and provide required 24 volt control wiring in conduit from control panel to interceptor.

.4 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.5 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements. Submit a copy of the letter prior to Substantial Performance of the Work.

.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 SUBMITTALS

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

.2 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 close-out data.

.3 Submit manufacturer/supplier installation certification letters as specified in Part 3 of this Section.

.4 Submit, prior to Substantial Performance of the Work, start-up or test data specified in Part 3 of this Section.

2 Products

2.1 SEALED COMBUSTION HOT WATER HEATER

.1 Bradford White EF-series with a Thermal Efficiency Rating of 94%. It shall be design certified by CSA International (formerly AGA and CGA) for 180°F (82°C) application, either with or without a separate storage tank. The tank shall be lined with Vitraglas® vitreous enamel and shall have a bolted hand hole cleanout. The tank shall have four extruded magnesium anode rods installed in separate head couplings.

.2 Water heater shall be equipped with stainless steel cold water inlet, Sediment Reduction System.

.3 The heater shall be insulated with Non-CFC foam. This water heater shall be equipped with an electronic ignition system, an ASME rated T&P relief valve and a premix closed combustion system for direct venting using 6" (152mm) PVC, CPVC, Polypropylene, or Stainless Steel vent pipe (ULC-S636 Standard).

.4 The water heater shall be factory assembled and tested.

.5 The water heater shall be approved for zero inch clearance to combustibles.

.6 A digital LCD display shall be integrated into the front and be an adjustable electronic thermostat to any temperature up to 180°F.

.7 A recycling Energy Cut Off (E.C.O.) shuts off all gas in the event of an overheat condition.

.8 The entire installation shall be made in compliance with provincial and local codes and ordinances

.9 Contacts, relays and any other hardware, compatible with building automation system protocol and required to connect heater(s) to BAS in accordance with BAS control points list.

.10 Acceptable manufacturers are:

- .1 Bradford White Canada Inc.;
- .2 A.O. Smith Water Products Co.;
- .3 John Wood (GSW Water Heating Co.);
- .4 Rheem-Ruud Canada Ltd..

2.2 CONDENSATE NEUTRALIZING KIT

.1 Refillable, low-profile condensate neutralizing kit, suitable for no less than 12 months continuous operation at full condensing rate, and suitable in all respects for associated condensing heater.

3 Execution

3.1 DRAINAGE COORDINATION

.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

.1 Provide gas fired domestic hot water heaters. Secure each heater in place, level, and plumb, on a concrete housekeeping pad.

.2 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.

.3 Pipe temperature/pressure relief valve outlet to drain. Pipe condensate drain connection to drain.

.4 Coordinate installation with electrical trade who will connect heater with power wiring.

.5 Set thermostat to produce 48.8°C (120°F) hot water.

.6 Provide combustion air and flue gas vent piping for each heater in accordance with requirements of Section 23 51 23 - Gas Vents.

.7 Install inlet and outlet manifolds supplied with heaters.

.8 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.9 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements. Submit a copy of the letter prior to Substantial Performance of the Work.

.10 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.

.11 Provide condensate neutralizing kit and install in accordance with manufacturer's instructions.

End of Section

1 General

1.1 SUBMITTALS

.1 Submit product data sheets (fixture cuts) for all plumbing fixtures and fittings.

2 Products

2.1 GENERAL RE: PLUMBING FIXTURES AND FITTINGS

.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 Barrier-free fixtures and fittings are to be in accordance with governing Code requirements.

.3 Unless otherwise specified, vitreous china, porcelain enamelled, and acrylic finished fixtures are to be white.

.4 Unless otherwise specified, fittings and piping exposed to view are to be chrome plated and polished.

.5 Fittings located in areas other than private washrooms are to be vandal-proof.

.6 Fixture carriers are to be suitable in all respects for the fixture they support and construction in which they are located.

.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.

.8 Proper seal to mate with fixture carrier flange and produce a water-tight installation.

.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.

.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.

.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.

.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.

2.2 PLUMBING FIXTURES AND FITTINGS

.1 Plumbing fixtures and fittings are to be in accordance with the following:

.1 WC-1 – WALL MOUNTED ELONGATED ELECTRONIC FLUSH VALVE WATER CLOSET

.1 American Standard 3351.511.020 Toilet Wall-mounted elongated flushometer valve toilet, Combination Flush Valve and Toilet, Vitreous china, White, Toilet, 1-1/2" inlet top spud, Elongated, Powerful direct-fed siphon jet action, Fully-glazed 2-1/8" trapway, 1,000 grams of miso @ 1.1gpf, 660 x 356 x 381mm (26" x 14" x 15"), High Efficiency.

.2 American Standard 6065.111 Flush valve, Factory-Installed CR-P2 Lithium 10-year Battery, Self-Cleaning Piston with integral wiper spring significantly reduces clogging and maintenance, Selectronic® Proximity System with universal sensor, Dezincification Resistant, Fully Mechanical Manual Override Button, Fail-Safe, Adjustable Sanitary Flush, Chemical Resistant EPDM Seals, installed left or right handed, Operates in the range of 1.1 gpf to 1.6 gpf (4.2 Lpf to 6.0 Lpf), 25gpm (94.6 L/min.).

.3 Watts ISCA-101-D Carrier - Industry Standard Back-to-Back Horizontal Adjustable Closet Carrier, patented compression seal faceplate assembly, epoxy coated cast iron, epoxy coated cast iron, with incremental measurements embossed onto legs to easily adjust height of carrier to most commonly used fixture requirements, epoxy coated cast iron, plated hardware, neoprene bowl gasket, adjustable ABS nipple, integral test cap, 2"(51) no hub vent connections, 4"(102) no hub waste, Adjustable for standard and wheelchair height, chrome cap nuts, Carrier complies with requirements of ASME A112.6.1M up to a 500 lb.(227 kg.) static load.

.4 Centoco AMFR1500STSCCSSFE-001 Seat - Polypropylene, Commercial, Elongated, 2" (51mm), White, Open front, less cover, Commercial, 18 5/8" (473mm), 14 1/2" (368mm), Antimicrobial, Fire Retardant.

.5 Waste outlet seal ring neoprene or graphite-felt.

.2 WC-2 – WALL-MOUNTED ELONGATED ELECTRONIC FLUSH VALVE WATER CLOSET – BARRIER FREE

.1 American Standard 3351.511.020 Toilet Wall-mounted elongated flushometer valve toilet, Combination Flush Valve and Toilet, Vitreous china, White, Toilet, 1-1/2" inlet top spud, Elongated, Powerful direct-fed siphon jet action, Fully-glazed 2-1/8" trapway, 1,000 grams of miso @ 1.1gpf, 660 x 356 x 381mm (26" x 14" x 15"), High Efficiency.

.2 American Standard 6065.111 Flush valve, Factory-Installed CR-P2 Lithium 10-year Battery, Self-Cleaning Piston with integral wiper spring significantly reduces clogging and maintenance, Selectronic® Proximity System with universal sensor, Dezincification Resistant, Fully Mechanical Manual Override Button, Fail-Safe, Adjustable Sanitary Flush, Chemical Resistant EPDM Seals, installed left or right handed, Operates in the range of 1.1 gpf to 1.6 gpf (4.2 Lpf to 6.0 Lpf), 25gpm (94.6 L/min.).

.3 Watts ISCA-101-L/R-BF Carrier - Industry Standard Single Horizontal Carrier for Floor Mounted Back Outlet Bowl, patented compression seal faceplate assembly, epoxy coated cast iron, with incremental measurements embossed onto legs to easily adjust height of carrier to most commonly used fixture requirements, epoxy coated cast iron, plated hardware, neoprene bowl gasket, ABS nipple, integral test cap, 2"(51) no hub vent connections, 4"(102) no hub waste, chrome cap nuts.

.4 Franke Commercial CM-16104-WM Backrest - wall mounting, back rest, solid core plastic laminate panel back, antique white, 12" (305 mm), 4" (102 mm), 5 3/8" (137 mm), 18-gauge stainless steel bar with #4 gloss with flanges and covers, concealed snap flanges and mounting hardware included, Provide adequate backing in wall for support and comply to local codes for barrier free requirements.

.5 Centoco AMFR1500STSCCSSFE-001 Seat - Polypropylene, Commercial, Elongated, 2" (51mm), White, Open front, less cover, Commercial, 18 5/8" (473mm), 14 1/2" (368mm), Antimicrobial, Fire Retardant.

.6 Waste outlet seal ring neoprene or graphite-felt.

.3 L-1 – WALL HUNG LAVATORY

.1 American Standard 90240955.001EC w/0059.020EC Basin, Vitreous china, Wall-hung, White, Center hole only, 5" (127 mm) bowl depth, 343mm (13-1/2") front to back, 394mm (15-1/2") wide, 20 1/2" (520mm) bowl length, 21 1/4" (540mm) bowl width, 520mm (20.5") deep, 540mm (21-1/4") wide, 0059.020EC Shroud/Knee Contact Guard, Everclean Anti-microbial, Recessed self-draining deck, With Overflow, Top of front rim mounted 864mm (34") from finished floor., ASME A112.19.2 for Vitreous China Fixtures, For concealed arm or wall support

.2 American Standard 7075.100.002 Faucet - COLONY, Manual, Counter Mounted, single hole, metal body, Lavatory, Polished Chrome, 1.2 gpm/4.5 L/min. maximum flow rate., No Deck Plate, Fixed Spout, 4-5/16" (111 mm), 24" Color-coded braided flexible supply hoses with 3/8" compression connections, Ceramic Disc Valve Cartridge, Metal pop-up drain, Meets the Americans with Disabilities Act Guidelines and ANSI A117.1, Lead Free: Faucet contains less than or equal to 0.25% total lead content by weighted average, Metal lever handle, Single Handle, ASME A112.18.1, CSA B125.1, NSF 61/NSF 372.

.3 McGuire LFH170LK Supply - Lead Free, Chrome plated, Convertible loose key handle, Lavatory Supply

.4 McGuire PRODRAIN Fixture Drain - Patended Grid drain, Straight Drain, Lavatories without overflows, Heavy cast brass, Chrome plated, 17 gauge 1-1/4" (32 mm)Ø tailpiece diameter, 17 gauge 6" (152 mm) long tailpiece, Brass locknut, Heavy rubber basin washer Fiber friction washer, CSA compliant

.5 McGuire 8872C P-Trap - Heavy cast brass, Adjustable p-trap, 11-1/2" (292 mm) distance, With cleanout plug, Steel shallow flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend, ASME A112.18.2 CSA B125.2, CSA compliant

.6 Watts WCA-411-D- Carrier - Back-to-back Floor Mounted Lavatory Carrier with Concealed Arms, plated hardware

.4 L-2 - COUNTERTOP LAVATORY – BARRIER FREE

.1 American Standard 90240955.001EC w/0059.020EC Basin - BARRIER FREE, Vitreous china, Wall-hung, White, Center hole only, 5" (127 mm) bowl depth, 343mm (13-1/2") front to back, 394mm (15-1/2") wide, 20 1/2" (520mm) bowl length, 21 1/4" (540mm) bowl width, 520mm (20.5") deep, 540mm (21-1/4") wide, 0059.020EC Shroud/Knee Contact Guard, Everclean Anti-microbial, Recessed self-draining deck, With Overflow, Top of front rim mounted 864mm (34") from finished floor., ASME A112.19.2 for Vitreous China Fixtures, For concealed arm or wall support

.2 Chicago Faucets 116.122.AB.4 Faucet - Automatic, Deck mounted, Single Hole Centerset, ECAST construction with less than 0.25% lead content weighted, Single hole, HyTronic electronic faucet, Polished Chrome, 0.35 GPM (1.3 LPM) flow rate, Contemporary style integral spout, 5-1/8" (130 mm) projection from wall, Optional 1.5 GPM(5.7 LPM) flow rate aerator insert, Econo-flo non-aerating spray, Hardwired Operated, 12 volt AC transformer required, Stainless steel hose included, Dual-beam infrared sensor, Less Drain, ANSI/ICC A117.1,NSF/ ANSI 61,NSF/ANSI 372 Low Lead Content,ASME A112.18.1/CSA B125.1, CALGreen, 40-140° F operating temperature range, 20-125 PSI operating pressure range.

.3 Chicago Faucets 240.630.00.1 Transformer - 120 VAC 60Hz, Plug-in single use class 2A transformer, 115V Standard 2-prong outlet, 12 VAC, 50 mA, Short-circuit protection

.4 McGuire LFH170LK Supply - Lead Free, Chrome plated, Convertible loose key handle, Lavatory Supply

.5 McGuire PRODRAIN Fixture Drain - Patended Grid drain, Straight Drain, Lavatories without overflows, Heavy cast brass, Chrome plated, 17 gauge 1-1/4" (32 mm)Ø tailpiece diameter, 17 gauge 6" (152 mm) long tailpiece, Brass locknut, Heavy rubber basin washer Fiber friction washer, CSA compliant

.6 McGuire 8872C P-Trap - Heavy cast brass, Adjustable p-trap, 11-1/2" (292 mm) distance, With cleanout plug, Steel shallow flange, Neoprene gasket, Slipnuts, 17 gauge seamless tubular wall bend, ASME A112.18.2 CSA B125.2, CSA compliant

.7 Watts WCA-411-D- Carrier - Back-to-back Floor Mounted Lavatory Carrier with Concealed Arms, plated hardware

.5 S-1 - DOUBLE COMPARTMENT SELF RIMMING DROP-IN SINK WITH FAUCET LEDGE

.1 Franke Commercial LBD6408-1/1 Sink - Self Rimming, Stainless Steel, 302, 20 gauge, #4 Satin finish, Topmount Commercial Sinks, Double compartment, 1 faucet hole; 1 1/2" diameter, 1 1/2" (DN38) brass tailpiece, and standpipe with guard, 8" (203 mm), 16" (406 mm), 14" (356 mm), 8" (203 mm), 31 1/4" (794 mm), With faucet ledge, 3 1/2" crumb cup strainer, Center back waste location, Undercoated to reduce condensation and resonance, Factory applied rim seal, Certified to ASME A112.19.3-2008, Certified to CSA B45.4-08, factory installed EZ TORQUE™ fasteners

.2 American Standard 4433.300.075.F15 Faucet - QUINCE, Manual, Counter Mounted, single hole, metal body, Sink, Stainless Steel, 1.5 GPM (5.7 LPM) maximum flow rate, High arc swivel spout, Adjustable spray pattern with Washerless 40mm ceramic disc valve cartridge, 8 3/4", Braided flexible Stainless Steel supply hoses with 3/8" compression connections, Ceramic Disc Valve Cartridges, Less Drain, Meets the American Disabilities Act Guidelines and ANSI A117.1, Lead Free: Faucet contains less than or equal to 0.25% total lead content by weighted average, metal handle, Single Handle, Integral Check Valves, ASME A112.18.1, CSA B125

.3 McGuire LFCK165LK Supply - Lead Free, Pipe to compression, Integral Check Supply Kit, Chrome plated, 3/8" I.P.S x 3/8" O.D, 12" (305 mm) chrome plated risers, Loose key, Faucet, Shallow wall flange

.4 McGuire 8903C P-Trap - Heavy cast brass, Adjustable p-trap, 13-3/4" (349 mm) length, With cleanout plug, Shallow steel flange, Seamless tubular brass bend, Slipnuts

.6 S-2 – WALL HUNG SINK WITH FAUCET LEDGE

.1 Franke Commercial WSS6713/2 Sink - Wall Hung, Stainless Steel, 1.4301 Chrome Nickel steel V2A, 304, 14 gauge, #4 Satin finish, Satin finish, Service Sink, Single compartment, 2 faucet holes, 1 1/4" diameter, 8" centerset, no, 12" (305 mm), 13" (330 mm), 16" (406 mm), 17" (432 mm), 25" (635 mm), 20" (508 mm), With faucet ledge, 3 1/2" crumb cup strainer, Center waste location, Radius coved bowl corners, Certified to ASME A112.19.3-2008 / CSA B45.4-08

.2 American Standard 7293.172H.002 Faucet - Manual, Wall Mounted, 8" centerset spread, Cast Brass Construction, Mop Sink, Polished Chrome, 1.5 GPM (5.7 LPM) maximum flow rate., Rigid/swivel gooseneck spout, 8-1/2" (216 mm), Less Supply, Ceramic Disc Valve Cartridge, Less Drain, Lead Free: Faucet contains less than or equal to 0.25% total lead content by weighted average, Metal wrist blade handles, Two Handles, ANSI A117.1 ASME A112.18.1 CSA B125 NSF 61/Section 9

.3 McGuire LFCK165LK Supply - Lead Free, Pipe to compression, Integral Check Supply Kit, Chrome plated, 3/8" I.P.S x 3/8" O.D, 12" (305 mm) chrome plated risers, Loose key, Faucet, Shallow wall flange

.4 McGuire 8903C P-Trap - Heavy cast brass, Adjustable p-trap, 13-3/4" (349 mm) length, With cleanout plug, Shallow steel flange, Seamless tubular brass bend, Slipnuts

.7 S-1 - SINGLE COMPARTMENT SELF RIMMING DROP-IN SINK WITH FAUCET LEDGE

.1 Franke Commercial LBS7312P-1/1 Sink - Countertop, Stainless Steel, 304, 18 gauge, #4 Satin finish, Topmount Commercial Sinks, Single compartment, 1 faucet hole; 1 1/2" diameter, 1 1/2" (DN38) brass tailpiece, and standpipe with guard, 12" (305 mm), 17 1/2" (444 mm), 23 1/2" (597 mm), 12" (305 mm), 25 5/8" (651 mm), With faucet ledge, 3 1/2" crumb cup strainer, Center waste location, Undercoated to reduce condensation and resonance, Factory applied rim seal, Certified to ASME A112.19.3-2008, Certified to CSA B45.4-08, factory installed EZ TORQUE™ fasteners

.2 American Standard 4433.300.075 Faucet - QUINCE, Manual, Counter Mounted, single hole, metal body, Sink, Stainless Steel, 1.5 GPM (5.7 LPM) maximum flow rate, High arc swivel spout, Adjustable spray pattern with Washerless 40mm ceramic disc valve cartridge, 8 3/4", Braided flexible Stainless Steel supply hoses with 3/8" compression connections, Ceramic Disc Valve Cartridges, Less Drain, Meets the American Disabilities Act Guidelines and ANSI A117.1, Lead Free: Faucet contains less than or equal to 0.25% total lead content by weighted average, metal handle, Single Handle, Integral Check Valves, ASME A112.18.1, CSA B125

.3 McGuire LFCK165LK Supply - Lead Free, Pipe to compression, Integral Check Supply Kit, Chrome plated, 3/8" I.P.S x 3/8" O.D, 12" (305 mm) chrome plated risers, Loose key, Faucet, Shallow wall flange

.4 McGuire 8903C P-Trap - Heavy cast brass, Adjustable p-trap, 13-3/4" (349 mm) length, With cleanout plug, Shallow steel flange, Seamless tubular brass bend, Slipnuts

.8 MS-1 - MOP SINKS

.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 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

.3 Trap - 3" (75 mm) diameter cast iron or rough copper "P" trap.

.9 SH-1 - PRESSURE BALANCING SHOWER SYSTEM WITH SHOWER HEAD

.1 Chicago Faucets SH-PB1-07-000 Complete Shower Trim - Polished Chrome, Pressure balancing shower system with shower head and valve trim options, 1.5 GPM (5.7 LPM) flow rate @ 80 PSI, Showerhead with adjustable spray

.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

.3 Trap – provide P-Trap, same material as the connecting pipe drain.

.10 SH-2 - PRESSURE BALANCING SHOWER SYSTEM WITH SHOWER HEAD, HAND SPRAY, AND DIVERTER – BARRIER FREE

.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 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

.3 Trap – provide P-Trap, same material as the connecting pipe drain.

.11 EW-1 - EYE/FACE WASH, WALL MOUNTED, STAINLESS STEEL BOWL

.1 Guardian G1750TPG3600LF Emergency Equipment - Thermostatic mixing valve blends hot and cold water, 1-1/2" (38 mm) outer diameter chrome plated brass tailpiece, Eye/face wash with stainless steel bowl, Wall mounted, Corrosion resistant powder coated finish, 11-1/8" (283 mm) Ø bowl size, Two FS-Plus spray heads with flip top dust cover each, 1/2" (13 mm) Ø IPS Chrome plated brass stay open ball valve, 1/2" (13 mm) Ø NPT female inlet, 1-1/4" (32 mm) Ø NPT female outlet, Heavy duty cast aluminum wall bracket, ANSI compliant

2.3 ACCEPTABLE MANUFACTURERS

.1 Subject to compliance with requirements, manufacturers that may be incorporated into the Work include, but are not limited to, following:

.1 Flush Valves:

.1 Sloan;

.2 Delta Commercial;

.3 Zurn Industries;

.4 American Standard;

.5 Moen Commercial.

.2 Plumbing Brass:

.1 Sloan;

.2 Acorn Engineering;

.3 American Standard;

.4 Delta Commercial;

.5 Chicago Faucet;

.6 Moen Commercial.

.3 Stainless Steel Sinks:

.1 Franke Commercial;

.2 Novanni Commercial;

.3 Aristaline;

.4 Arch Metal Ind.

.4 Mop Sinks:

.1 Stern Williams;

.2 Acorn Engineering;

.3 Zurn Industries.

.5 Drain Fittings, Angle Supplies, and Traps:

.1 McGuire;

.2 American Standard;

.3 Delta Commercial;

.4 Zurn Industries.

.6 Fixture Carriers:

.1 Watts Industries;

.2 Jay R. Smith;

.3 Zurn Industries.

.7 Water Closets, Lavatories, and Urinal:

.1 American Standard;

.2 Zurn Industries;

.3 Kohler.

.8 Thermostatic Mixing Valves:

.1 Lawler;

.2 Delta Commercial;

.3 Leonard.

.9 Shower and Associated Trim:

.1 American Standard;

.2 Delta Commercial;

.3 Zurn Industries;

.4 Moen Commerical.

.10 Toilet Seats:

.1 Olsonite;

.2 Centoco;

.3 Bemis Commercial.

2.4 CAULKING

.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 Consultant from sealant manufacturer’s standard colour range.

3 Execution

3.1 INSTALLATION OF PLUMBING FIXTURES AND FITTINGS

.1 Provide required plumbing fixtures and fittings.

.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 below, provide piping accordingly:

FIXTURE AND/OR FITTING	DRAIN SIZE MM (IN.)	VENT SIZE MM (IN.)	DHW SIZE MM (IN.)	DCW SIZE MM (IN.)	TEMP WATER SIZE MM (IN.)
Water Closets Tank Type	75 (3)	38 (1-½)	-----------	12 (½)	-----------
Urinals	75 (3)	38 (1-½)	-----------	25 (1)	-----------
Lavatories	32 (1-¼)	32 (1-¼)	12 (½)	12 (½)	-----------
Counter Sinks	38 (1-½)	32 (1-¼)	12 (½)	12 (½)	-----------
Shower Valves and Heads	-----------	-----------	12 (½)	12 (½)	12 (½)
Shower Stalls	50 (2)	38 (1-½)	12 (½)	12 (½)	12 (½)
Prefab. Mop Sinks with Drain	75 (3)	38 (1-½)	20 (¾)	20 (¾)	-----------

.3 Confirm exact location of plumbing fixtures and trim prior to roughing-in. Refer to architectural plan and elevation drawings.

.4 When installation is complete, check, and test operation of each fixture and fitting. Adjust or repair as required.

.5 For barrier-free fixtures, comply with mounting height and other requirements of governing Code(s).

.6 Supply templates for counter mounted fixtures and trim and hand to trades who will cut the counter. Ensure openings in counter are properly located.

.7 Protect shower bases from damage during construction and finishing work.

.8 Confirm exact mixing valve and shower head locations prior to roughing-in.

.9 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.

.10 For emergency showers, install so bottom of shower head is approximately 2 m (82") above floor, and approximately 400 mm (16") out from the wall. Wall mount mixing valve approximately 1.5 m (5') 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.

.11 Install eye wash fixtures in accordance with manufacturer’s instructions. Ensure exposed piping is painted.

.12 Wall mount mixing valves for emergency fixtures approximately 1.5 m (5') 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.

.13 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

.1 Caulk around plumbing fixtures and fittings where they contact walls, floors, and any other building surface.

.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 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.

.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

.1 Provide roughed-in water and drain connections for Owner supplied dishwasher consisting of:

- .1 15 mm (½") dia. domestic hot water connection with a Dahl "Mini-Ball" valve with hose end and water hammer arrestor;
- .2 40 mm (1-½") dia. DWV copper drain connection with “P” trap and cleanout plug.

3.4 CLOTHES WASHER CONNECTIONS

.1 Provide roughed-in water and drain connections for Owner supplied clothes washer consisting of:

- .1 15 mm (½") dia. piping connection for both hot and cold water, each terminated in a Dahl "Mini-Ball" Valve with hose end and water hammer arrestor;
- .2 40 mm (1-½") dia. standing waste with a height to suit the washer drain and complete with a “P” trap.

3.5 GEAR EXTRACTOR CONNECTIONS

.1 Provide roughed-in water and drain connections for Owner supplied clothes washer consisting of:

- .1 20 mm (¾") 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.
- .2 75 mm (3”) dia. drain down to trench.

End of Section

1 General

1.1 SUBMITTALS

.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.

.2 For each gas pressure regulating station, submit:

.1 a selection sheet for each PRV, indicating connected equipment, heating loads, design allowance, meter model, body size, spring range and orifice size;

.2 a selection sheet for each relief valve(s) serving a PRV.

1.2 QUALITY ASSURANCE

.1 All gas system work is to be in accordance with requirements of CAN/CSA-B149.1, Natural Gas and Propane Installation Code, as amended by local Gas Codes.

.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.

.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

.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 Polyethylene: Safety yellow coloured polyethylene pipe, fittings, and joints to CSA-B137.4.

.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.

.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.

.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.

.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 45º flare type, forged or with a machined long nut and copper to copper threaded connectors, and, where required, flared brass copper to NPS adapters.

.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. Acceptable products are:

.1 Tru-Flex Metal Hose LLC. "Pro-Flex";

.2 Titeflex Corp. "Gastite";

.3 Omega Flex Canada "TracPipe".

2.2 PIPING UNIONS

.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 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.

.3 Copper to Steel: Equal to Kamco Products "Copper Stopper".

2.3 EARTHQUAKE ACTIVATED AUTOMATIC SHUT-OFF VALVE

.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

.1 Ball Type: 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. Acceptable products are:

.1 Neo Valves Inc. #425;

.2 Kitz Corp. Code 58;

.3 Toyo Valve Co. Fig. 5044A.

2.5 PRESSURE REGULATORS

.1 CSA certified pressure regulators as follows:

.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 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 Acceptable manufacturers are:

.1 Maxitrol Co.;

.2 Fisher Controls;

.3 Leslie Controls Inc.;

.4 Lakeside Process Controls.

3 Execution

3.1 NATURAL GAS SERVICE

.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.

.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.

3.2 NATURAL GAS PIPING INSTALLATION REQUIREMENTS

.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.

.2 Piping is to be as follows:

- .1 for underground piping, coated Schedule 40 black steel, coated soft copper, or polyethylene;
- .2 for above ground piping, uncoated Schedule 40 black steel, hard temper or soft copper, or, if permitted, flexible stainless steel.

.3 Install flexible stainless-steel pipe in strict accordance with the pipe manufacturer's printed instructions.

.4 Slope gas piping in the direction of flow to low points.

.5 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.

.6 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.

.7 Identify all natural gas piping above ground with two coats of safety yellow enamel applied over primer, and SMS Ltd. or equal coil type vinyl identification makers with arrows.

.8 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.

.9 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.

.10 Include for mounting only of a solenoid valve in the gas piping to kitchen cooking equipment.

3.3 INSTALLATION OF SHUT-OFF VALVES

.1 Provide CSA approved ball type or lubricated plug type shut-off valves to isolate equipment, and wherever else shown.

.2 Ensure that valves are located for easy accessibility and maintenance.

3.4 INSTALLATION OF NATURAL GAS CONVENIENCE OUTLETS

.1 Provide natural gas convenience outlets and wall mount.

.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

.1 Provide pressure regulators in gas distribution piping where indicated and/or required.

.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 Use vented type pressure regulators for all other applications.

.4 Install regulating stations in accordance with requirements of CAN/CSA-B149.1.

.5 Provide 6 mm (¼") diameter test ports upstream and downstream of each regulator assembly.

.6 Locate outdoor regulating stations 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.

.7 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.

.8 Indicate operating set-points, relief settings and vent arrangements for each regulating station on as-built record drawings.

End of Section

1 General

1.1 SUBMITTALS

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

.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 Consultant for review.

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

1.2 QUALITY ASSURANCE

.1 Refrigerant piping systems are to be in accordance with CSA B52, Mechanical Refrigeration Code, and any applicable local Codes and Regulations.

.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.

.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

.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

.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

.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

.1 Ball Valves

  .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 Acceptable manufacturers are:

    .1 Mueller Industries Inc.;
    .2 Sporlan Valve Co.;
    .3 Superior Refrigeration Products/Sherwood.

.2 Diaphragm Valves

.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 Acceptable manufacturers are:

.1 Mueller Industries Inc.;

.2 Sporlan Valve Co.;

.3 Superior Refrigeration Products/Sherwood.

2.5 CHECK VALVES

.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:

.1 straight through type check valves complete with a machined brass gasketed body, phosphor bronze spring, and neoprene seat;

.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 Acceptable manufacturers are:

.1 Mueller Industries Inc.;

.2 Sporlan Valve Co.;

.3 Superior Refrigeration Products/Sherwood.

2.6 PIPING TRAPS

.1 Mueller Industries Inc. Style No. WE-554P brazing end copper "P" traps.

.2 Acceptable manufacturers are:

.1 Mueller Industries Inc.;

.2 Sporlan Valve Co.;

.3 Superior Refrigeration Products/Sherwood.

2.7 PRESSURE VESSEL RELIEF VALVES

.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 Acceptable manufacturers are:

.1 Mueller Industries Inc.;

.2 Sporlan Valve Co.;

.3 Superior Refrigeration Products/Sherwood.

2.8 REFRIGERANT LIQUID MOISTURE INDICATORS

.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 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 Acceptable manufacturers are:

.1 Mueller Industries Inc.;

.2 Sporlan Valve Co.;

.3 Superior Refrigeration Products/Sherwood.

2.9 LIQUID LINE FILTER-DRIER

.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 Acceptable manufacturers are:

.1 Mueller Industries Inc.;

.2 Sporlan Valve Co.;

.3 Superior Refrigeration Products/Sherwood.

2.10 FLEXIBLE PIPING CONNECTIONS

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

.2 Acceptable manufacturers are:

.1 Senior Flexonics Canada;

.2 The Metraflex Co.

3 Execution

3.1 INSTALLATION OF REFRIGERANT PIPING, VALVES AND SPECIALTIES

.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.

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

.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.

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

.6 Provide refrigerant piping accessories shown and/or required and install in accordance with manufacturer’s recommendations.

.7 Provide required refrigerant.

.8 Provide flexible connections at piping connections to roof mounted condensing units. Install in accordance with manufacturer’s instructions.

End of Section

1 General

1.1 SUBMITTALS

.1 Submit shop drawings/product data sheets for all products specified in this section except shop fabricated ductwork and fittings.

.2 Include capacity, throw and terminal velocity, noise criteria, and pressure drops with grille and diffuser shop drawing/product data sheet submission.

.3 With shop drawing/product data sheet submission, supply evidence that fire rated duct manufacturer is ULC listed to size requirements shows on drawings.

.4 Submit duct leakage test data prior to ductwork being covered from view.

.5 Submit manufacturer’s colour chart(s) for all items for which a finish colour is to be selected.

.6 Submit proper installation certification from fire rated duct manufacturer as specified in Part 3 of this section.

.7 Submit a site inspection and start-up report from fan filter diffuser manufacturer’s representative as specified in Part 3 of this section.

.8 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.

.9 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.

1.2 QUALITY ASSURANCE

.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

.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 Rectangular

.1 Lock forming grade hot dip galvanized steel, ASTM A653, shop fabricated, minimum #26 gauge.

.3 Round

.1 Factory machine fabricated, spiral, mechanically locked flat seam, single wall duct, fittings and couplings.

2.2 FLEXIBLE DUCTWORK

.1 Acoustic Flexible Ducting: CEH – Type HPB by Peppertree Air Solutions Inc. The core will be constructed of a spirally wound strip of acoustic rated CPE interlocked with an external helix; wrapped in Owens Corning GREENGUARD Children & Schools Certified FIBERGLAS® insulation; and sleeved by a black flame retardant low-density antistat polyethylene vapor barrier. CEH-HPB is ULC-S110 Listed as a Class 1 Air Duct Connector with a Flame Spread Rating of not over 25 without evidence of continued progressive combustion and a Smoke Developed Rating of not over 50.

.2 Elbow Brace: Equal to Titus, FlexRight brace to provide support for 90 degree elbows.

2.3 FLEXIBLE CONNECTION MATERIAL

.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. Acceptable products are:

.1 Duro Dyne Canada Inc. "DUROLON";

.2 Dyn Air Inc. "HYPALON".

.2 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. Acceptable products are:

.1 Duro-Dyne Canada Inc. "THERMAFAB";

.2 Dyn Air Inc. "SILICON HI-T".

2.4 METAL DUCT SYSTEM JOINT SEALANT

.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 Acceptable manufacturers are:

.1 Johns Manville;

.2 Manson Insulation;

.3 Knauf Insulation.

2.5 ACOUSTIC LINING

.1 Minimum 25 mm (1") thick acoustic lining material meeting NFPA 90A requirements and flame spread and smoke developed fire hazard ratings of CAN/ULC-S102, flexible for round ducts, board type for rectangular ducts, consisting of a closed cell, elastomeric, nitrile rubber insulation.

.2 Acceptable manufacturers are:

.1 Johns Manville;

.2 Manson Insulation;

.3 Knauf Insulation.

2.6 KITCHEN EXHAUST DUCT EXPANSION JOINT

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

2.7 FACTORY INSULATED RECTANGULAR/SQUARE KITCHEN GREASE EXHAUST DUCT

.1 Equal to DuraSystems "DuraDuct KEX" kitchen exhaust duct, 2 hour rated kitchen exhaust listed and labelled to CAN/ULC S144, and meeting requirements of NFPA 96. Duct is constructed of minimum #16 gauge black sheet steel inner liner, high temperature fibre insulation and a minimum #24 gauge galvanized steel outer jacket, and complete with required fittings and accessories, including access and cleanout fittings where required. Factory-fabricated grease duct assembly is to not require additional wraps or enclosures to achieve required fire resistance rating.

2.8 ROUND TO RECTANGULAR DUCT CONNECTIONS

.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.

2.9 SPLITTER DAMPERS

.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.

2.10 AIR TURNING VANES

.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 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.

2.11 MANUAL BALANCING (VOLUME) DAMPERS

.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:

  .1 hexagonal or square shaft extension through frame;

  .2 non-stick, non-corrosive synthetic bearings for rectangular dampers, flange stainless steel bearings for round dampers;

  .3 blade stops for single blade dampers, designed to prevent blade from moving more than 90°;

  .4 linkage for multiple blade dampers;

  .5 locking hand quadrant damper operator with, for insulated ducts 50 mm (2") standoff mounting.

.2 Rectangular Dampers: Nailor Industries Inc. 1800 Series, maximum size 1.2 m x 1.2 m (4' x 4') for a single damper.

.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.

.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.

.5 Acceptable manufacturers are:

  .1 Nailor Industries Inc.;

  .2 T.A. Morrison & Co. Inc. "TAMCO";

  .3 NCA Manufacturing Ltd.;

  .4 Greenheck Fan Corp.;

  .5 Ruskin Co.

2.12 BACKDRAFT DAMPERS

.1 Nailor Industries Model 1370CB counterbalanced backdraft dampers, vertical or horizontal mounting, 50 mm (2") wide, sized as shown and complete with:

  .1 extruded 6063-T5 aluminum frame, 2.3 mm (0.090") nominal wall thickness, with mitred corners;

  .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;

  .3 corrosion-resistant synthetic bearings;

  .4 adjustable plated steel counterweights mounted internally in the airstream;

  .5 concealed blade linkage located out of the airstream.

.2 Acceptable manufacturers are:

.1 Nailor Industries Inc.;

.2 T.A. Morrison & Co. Inc. "TAMCO";

.3 NCA Manufacturing Ltd.;

.4 Greenheck Fan Corp.;

.5 Ruskin Co.

2.13 FUSIBLE LINK DAMPERS

.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 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.

.3 Acceptable manufacturers are:

.1 Nailor Industries Inc.;

.2 Greenheck Fan Corp.;

.3 NCA Manufacturing Ltd.;

.4 Ruskin Co.;

.5 Price Industries (E.H. Price).

.6 Alumavent.

2.14 DUCT ACCESS DOORS

.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.

2.15 DUCTWORK DRAIN POINTS

.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.

2.16 INSTRUMENT TEST PORTS

.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.

2.17 WIRE MESH (BIRDSCREEN)

.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.

2.18 LOUVRES

.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 Louvres are to be factory finished with a finish equal to PPG Industries "Duranar" fluoropolymer powder coating over primer with colour as selected from manufacturer’s standard colour range.

.3 Acceptable manufacturers are:

.1 Price Industries Inc.;

.2 The Airolite Co. LLC;

.3 Construction Specialities;

.4 Nailor Industries Inc.;

.5 Kinetics Noise Control Inc.

.6 Greenheck Fan Corp.

.7 Alumavent.

.8 Ventex.

2.19 WALL BOXES

.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 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.

2.20 GRILLES AND DIFFUSERS

.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 Acceptable manufacturers are:

.1 Price Industries Inc.;

.2 Anemostat;

.3 Krueger Division of Air System Components Inc.;

.4 Titus;

.5 Nailor Industries Inc.;

.6 Tuttle & Bailey.

3 Execution

3.1 CLEANLINESS REQUIREMENTS FOR HANDLING AND INSTALLATION OF DUCTWORK

.1 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

.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.

.2 It is to be understood that all duct dimensions shown on drawings are clear internal dimensions.

.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. Duct system sealing is to meet ANSI/SMACNA Seal Class A requirements.

.4 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 Consultant. Duct routing and/or dimension revisions to suit conditions at site are not grounds for a claim for an extra cost.

.5 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.

.6 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.

.7 Install (but do not connect) duct system mounted automatic control components supplied as part of the automatic control work.

.8 Where indicated, provide duct connections to fan powered heat transfer equipment with integral coils.

.9 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.

.10 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 Consultant.

.11 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.

.12 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.

.13 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:

- .1 ductwork outside building or otherwise exposed to the elements;
- .2 shower exhaust ducts from grilles to duct main or riser;
- .3 minimum of 3 m (10') upstream and downstream of duct mounted humidifiers or humidifier manifolds;
- .4 fresh air intakes;
- .5 wherever else shown.

.14 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.

.15 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.

.16 Clean exterior exposed (uninsulated) ducts and coat with a heavy full coverage of Bakor #410-02 black metal paint.

.17 Where dissimilar metal ducts are to be connected, isolate ducts by means of flexible duct connection material.

.18 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.

3.3 INSTALLATION OF FLEXIBLE DUCTWORK

.1 Provide maximum 3 m (10') 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.

.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 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.

.4 Do not penetrate fire barriers with flexible duct.

3.4 INSTALLATION OF ACOUSTIC LINING

.1 Provide acoustic lining in ductwork in locations as follows:

  .1 wherever shown and/or specified on drawings;

  .2 all transfer air ducts.

.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 SHEET STEEL KITCHEN GREASE EXHAUST DUCTWORK

.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.

.2 Clean and prime coat ground welds in black steel ducts.

.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 reside might collect, and locate access door/cleanouts for ease of maintenance.

.4 Slope horizontal ductwork 25 mm per 300 mm (1" per foot) back to exhaust hood.

3.6 INSTALLATION OF ROUND TO RECTANGULAR DUCT CONNECTIONS

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

3.7 INSTALLATION OF SPLITTER DAMPERS

.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.

3.8 INSTALLATION OF TURNING VANES

.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.

.2 Provide volume extractor type turning vanes in short branch supply duct connections off mains to grilles and diffusers where shown and/or specified.

3.9 INSTALLATION OF MANUAL BALANCING (VOLUME) DAMPERS

.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.

.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 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.

3.10 INSTALLATION OF BACKDRAFT DAMPERS

.1 Provide backdraft dampers.

.2 Install and secure dampers so they cannot move or rattle.

3.11 INSTALLATION OF FUSIBLE LINK DAMPERS

.1 Provide fusible link dampers. Ensure damper rating (1-½ or 3 hr.) is suitable for fire barrier it is associated with.

.2 Do not use Type ‘A’ dampers where duct height is less than or equal to 300 mm (12”).

.3 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.

.4 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.

3.12 INSTALLATION OF FLEXIBLE CONNECTION MATERIAL

.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.

.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.

3.13 INSTALLATION OF DUCT ACCESS DOORS

.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.

.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 When requested, submit a sample of proposed duct access doors for review.

.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.

3.14 INSTALLATION OF INSTRUMENTS TEST PORTS

.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.

.2 Locate test ports where recommended by personnel performing air quantity testing and balancing work.

3.15 INSTALLATION OF WIRE MESH (BIRDSCREEN)

.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.

.2 Provide wire mesh panels for open-end return air ducts in ceiling spaces whether shown on drawings or not.

3.16 INSTALLATION OF LOUVRES

.1 Provide louvres for wall openings.

.2 Install louvre assemblies and secure in place in accordance with manufacturer's instructions and details.

.3 Confirm exact louvre sizes and finish prior to ordering.

3.17 INSTALLATION OF WALL BOXES

.1 Supply brick or block vents for installation in exterior walls.

.2 Hand assemblies to masonry trade for installation.

.3 Accurately mark exact locations and coordinate installation.

3.18 INSTALLATION OF GRILLES AND DIFFUSERS

.1 Provide grilles and diffusers. Wherever possible, grilles and diffusers are to be product of same manufacturer.

.2 Unless otherwise specified connect grilles and diffusers in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible.

.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.

.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.

.5 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).

.6 Confirm grille and diffuser finishes prior to ordering.

3.19 SUPPLY OF DOOR GRILLES

.1 Supply door grilles as shown and scheduled.

.2 Hand grilles to appropriate trade at site for installation.

3.20 DUCT SYSTEM PROTECTION, CLEANING AND START-UP

.1 Temporarily cover all open ends of ducts during construction.

.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 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.

.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.

.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 Submit shop drawings/product data sheets for fans and accessories. Include following:

.1 certified fan performance curves at specified operating point with flow, static pressure and HP clearly plotted;

.2 certified sound power data that conforms to specified levels;

.3 product data sheets for all accessories;

.4 product data sheets for fan motors.

.2 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.

.3 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this section.

.4 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.

.5 Submit a signed copy of destratification fan manufacturer's 5 year extended parts and labour warranty.

1.2 QUALITY ASSURANCE

.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 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;

.2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;

.3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;

.4 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;

.5 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans.

2 Products

2.1 ROOF MOUNTED EXHAUST FANS

.1 Centrifugal, ULC listed, factory run tested roof mounted exhaust fans in accordance with drawing schedule.

.2 Spun aluminium housing with deep venturi inlet, aluminium curb cap with continuously welded corners, pre-punched mounting holes, galvanized steel or aluminium birdscreen, and EMT conduit chase to the motor compartment.

.3 Centrifugal, non-overloading aluminum wheel with backward inclined blades matched to inlet venturi, statically and dynamically balanced as an assembly.

.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.

.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.

.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.

.7 For fans as scheduled, factory supplied accessories as follows:

- .1 non-corrosive low leakage Class A motorized damper with linkage, end switch, and motor with voltage to match fan motor;
- .2 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;
- .3 factory secured seismic restraint connection hardware.

.8 Acceptable manufacturers are:

- .1 Twin City Fan and Blower;
- .2 Loren Cook Co.;
- .3 Greenheck Fan Corp.;
- .4 JencoFan;
- .5 Carnes Company Inc.
- .6 Penn Barry.

2.2 CEILING MOUNTED DESTRATIFICATION FANS

.1 Big Ass Fan Co. Powerfoil X3.0, down-blowing, extra heavy-duty industrial grade, CSA certified direct drive ceiling mount destratification fans in accordance with drawing schedule, each meeting the following:

- .1 Regulatory Requirements:
  - .1 The entire fan assembly shall be Intertek/ETL-certified and built pursuant to the construction guidelines set forth by UL standard 507 and CSA standard 22.2 No. 113.
  - .2 The controller shall be compliant with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) The device may not cause harmful interference, and (2) The device must accept any interference received, including interference that may cause undesirable operation.
- .2 Onboard Fan Control
  - .1 The onboard fan controller shall be constructed using a variable frequency drive (VFD) that is pre-wired to the motor and factory-programmed to minimize the starting and braking torques for smooth and efficient operation. The onboard controller shall be prewired to the motor using a short run of flexible conduit with a dedicated ground conductor to minimize electromagnetic interference (EMI) and radio frequency interference (RFI). A 15-ft incoming power cord shall be pre-wired to the controller with one of the following plugs: NEMA L6-20P Twist-Lock Plug, NEMA L6-30P Twist-Lock Plug, NEMA L15-20P Twist Lock Plug, NEMA L16-20P Twist-Lock Plug.
- .3 Airfoil System
  - .1 The fan shall be equipped with eight (8) airfoils of precision extruded aluminum alloy. The airfoils shall be connected by means of two (2) high strength locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
  - .2 The fan shall be equipped with eight (8) winglets (standard) on the ends of the airfoils and eight (8) air fences positioned on the airfoils at the optimum location for performance. Both the winglets and air fences shall be molded of a polypropylene blend. The standard color of the winglet and air fence shall be “Safety Yellow.”
- .4 Motor

.1 The fan motor shall be an AC induction type inverter/

.2 The motor shall be totally enclosed, fan cooled (TEFC) with an IP44 NEMA classification. A NEMA 56C standard frame shall be provided for ease of service. The motor shall be manufactured with a double baked Class F insulation and be capable of continuous operation in 32ºF to 122ºF (0ºC to 50ºC) ambient conditions.

.3 The motor shall have a C-face attachment that shall enable technicians to detach the motor for easy field service. The C-face motor adapter shall be designed to work with the gearbox.

.5 Gearbox

.1 The fan gearbox shall be a sealed drive designed specifically for the airfoils series being used. The gearbox shall include a high-efficiency, hermetically sealed, nitrogen-filled, offset helical gear reducer with two-stage gearing, a hollow output shaft, cast iron housing, double lip seals, high quality SKF Explorer Series bearings with crowned cages for optimal lubrication flow, and precision machined gearing to maintain backlash less than 11 arc-minutes over the life of the unit. Lubrication shall be high-grade, low-foaming synthetic oil with extreme pressure additives and a wide temperature range and shall be lubricated for the life of the product (no oil changes required).

.2 The gearbox shall be equipped with a hollow shaft threaded to accept a ¾” NPT fitting in which wiring, piping, etc., can be routed to below the fan. A standard junction box can be affixed to this hollow shaft to allow for installing optional features such as lights or cameras. The inclusion of the hollow shaft shall be specified at the time of order.

.6 Mounting Post

.1 The fan shall be equipped with a mounting post that provides a structural connection between the fan assembly and extension tube. The mounting post shall be formed from A36 steel, contain no critical welds, and be powder coated for corrosion resistance and appearance.

.7 Mounting System

.1 The fan mounting system shall be designed for quick and secure installation on a variety of structural supports. The design of the upper mount shall provide two axes of rotation. This design shall allow for adjustments to be made after the mount is installed to the mounting structure to ensure the fan will hang level from the structure.

.2 The upper mount shall be of ASTM A-36 steel, at least 3/16” thick, and powder coated for appearance and corrosion resistance. No mounting hardware or parts substitutions, including cast aluminum, are acceptable.

.3 All mounting hardware shall be SAE Grade 8 or equivalent.

.8 Hub

.1 The fan hub shall be 19” (48 cm) in diameter and shall be made of precision cut aluminum for high strength and light weight. The hub shall consist of two (2) aluminum plates, eight (8) aluminum spars, and one (1) aluminum spacer fastened with a pin and collar rivet system. The overall design shall provide a flexible assembly such that force loads experienced by the hub assembly shall be distributed over a large area to reduce the fatigue experienced at the attachment point for the fan blade.

.2 The hub shall be secured to the output shaft of the gearbox by means of ten (10) high strength bolts. The hub shall incorporate four (4) safety retaining clips made of 1/4” (0.6 cm) thick steel that shall restrain the hub/airfoil assembly.

.9 Advanced Digital Fan Controller

.1 The digital controller user interface shall be a wall-mounted touchscreen with a 5-inch (127-mm) display and an 800 (RGB) x 480 pixel resolution.

.2 The digital controller shall be mounted to a standard rectangular or square outlet box.

.3 A 150-ft (45.7-m) CAT5 cable shall be provided for connecting the digital controller to the fan's VFD, allowing for seamless communication between controller and VFDs. The cable shall provide power to the digital controller.

.4 The digital controller shall not require a 120 V power supply at the controller mounting location.

.5 The digital controller shall support up to eight Powerfoil X3.0 or Powerfoil X3.0 Plus fans controlled as a group or individually.

.6 The digital controller shall provide fan start/stop, speed, and direction control functions.

.7 The digital controller shall provide diagnostic and fault history information for each connected fan as well as the ability to configure fan parameters with the assistance of Manufacturer Customer Service.

.8 The digital controller shall include Smart Sensing functionality to maximize energy savings. Smart Sensing shall provide the capability to automatically control the speed of the fans using information from user-determined settings and built-in temperature and humidity sensors.

.9 The digital controller shall include a scheduling feature that shall provide the ability to create up to four fan schedules for turning fans on/off and turning Auto mode on/off.

.10 The digital controller interface shall be able to be secured with user and admin passcodes to prevent unauthorized access to fan controls and settings.

.11 The digital controller shall include Bluetooth® functionality for receiving firmware updates from a mobile app. The app shall be supported by iOS® and Android™ mobile devices. The digital controller's Bluetooth functionality can be disabled if not needed or permitted.

.12 Multi-Fan Accessory Kit

.1 The kit shall include a two-screw RJ45 terminal block, a ¼ Watt, 120 Ohm termination resistor, RJ45 pass through splitters, and split-gland cord grips for connecting multiple fans to the controller.

.10 Fire Control Panel Integration

.1 Includes a 10–30 VDC pilot relay for seamless fire control panel integration. The pilot relay can be wired Normally Open or Normally Closed in the field.

.11 Factory secured seismic restraint connection hardware.

.12 Safety Cables

.1 The fan shall be equipped with an upper safety cable that provides an additional means of securing the fan assembly to the building structure. The upper safety cable shall have a diameter of Ø3/8" (1 cm).

.2 The fan shall be equipped with two lower safety cables pre-attached to the fan hub that shall provide an additional means of securing the fan to the extension tube. The lower safety cables shall have a diameter of 1/4" (0.6 cm).

.3 The safety cables shall be fabricated out of 7 x 19 galvanized steel cable. The end loops shall be secured with swaged Nicopress® sleeves, pre-loaded and tested to 3,200 lbf (13,345 N).

.4 Field construction of safety cables is not permitted.

.2 Acceptable manufacturers are:

.1 Big Ass Fan Co.;

.2 Northwest Envirofan;

.3 Marley Engineered Products "Leading Edge".

3 Execution

3.1 INSTALLATION OF ROOF MOUNTED EXHAUST FANS

.1 Provide roof mounted exhaust fans.

.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 Install dampers in curb damper tray and secure in place.

.4 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls for Mechanical Systems.

.5 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.6 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.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.

3.2 INSTALLATION OF CEILING DESTRATIFICATION FANS

.1 Provide ceiling destratification fans.

.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 Plug each fan motor into an adjacent receptacle.

.4 Supply 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. Controller must not be mounted adjacent to or above a radiant heat source, near HVAC ventilation intakes/exhausts, on a poorly insulated exterior wall, or in a different temperature/humidity environment than the fans it will control. Additional mounting guidelines can be found in the Installation Guide.

.5 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls for Mechanical Systems.

.6 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.7 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.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.

End of Section

1 General

1.1 SUBMITTALS

.1 Submit shop drawings/product data sheets for the exhaust fan and accessories. Include following:

.1 certified fan performance curves;

.2 product data for all accessories;

.3 product data for fan motors.

.2 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.

.3 Submit a site inspection and start-up report from manufacturer’s representative as specified in Part 3 of this section.

.4 Supply reviewed copies of appropriate fan assembly shop drawings or product data to trade who will cut roof opening or provide wall opening for fan, and ensure openings are properly located.

1.2 QUALITY ASSURANCE

.1 Kitchen exhaust fan 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 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;

.2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;

.3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;

.4 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;

.5 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans;

.6 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations;

.7 ULC-S645, Power Ventilators for Commercial and Institutional Kitchen Exhaust Systems.

.2 Acceptable manufacturers are:

.1 CaptiveAire;

.2 Twin City Fan and Blower;

.3 Loren Cook Co.;

.4 Greenheck Fan Corp.;

.5 JencoFan;

.6 Carnes Company Inc.

.7 SpringAir.

2 Products

2.1 KITCHEN EXHAUST FANS

.1 Centrifugal, ULC listed and labelled, factory run tested up-blast type kitchen exhaust fans in accordance with drawing schedule.

.2 Spun aluminium housing with a rolled bead edge, aluminium curb cap and inlet venturi with continuously welded corners, pre-punched mounting holes, aluminum birdscreen, and EMT conduit chase to motor compartment.

.3 Centrifugal, non-overloading aluminium wheel with backward inclined blades matched to inlet venturi, statically and dynamically balanced as an assembly.

.4 ECM direct drive motors are to conform to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, mounted on vibration isolation in aluminum housing, and factory pre-wired to an NEMA 4 disconnect switch.

.5 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, damper tray, and a continuous non-corrosive piano type curb hinge to permit access to the 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.

.6 For fans as scheduled, factory supplied accessories as follows:

  .1 gravity backdraft damper with #20 gauge galvanized steel frame and #26 gauge aluminum blades with felt edge blade seals;

  .2 non-corrosive motorized damper with linkage, end switch, and motor with voltage to match fan motor;

  .3 2-speed switch and 2-speed double winding 1-phase motor in accordance with Section 20 05 00 – Common Work Results for Mechanical;

  .4 factory secured seismic restraint connection hardware.

3 Execution

3.1 INSTALLATION OF KITCHEN EXHAUST FANS

.1 Provide kitchen hood exhaust fans.

.2 Supply a roof mounting curb with each fan and hand curb to roofing trade on roof for mounting and flashing into roof construction as part of the roofing work. Secure fan curb cap in place on curb. Test hinge operation and make any required adjustments.

.3 Install damper in curb damper tray and secure in place.

.4 Brace and secure the unit in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls or Mechanical Systems.

.5 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.6 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements. Include for supervising fan operation during hood performance testing.

3.2 DEMONSTRATION AND TRAINING

.1 Include for two, 4 hour on-site operation demonstration and training sessions for two groups of six people. 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 SUMMARY

.1 Provide all labour, materials, and equipment necessary to put in working operation a complete turnkey system to remove both diesel and automotive exhaust gases and particulate of operating vehicles within the confines of specified fire station(s). All necessary controls, motors, fittings, ductwork, blower(s), labor and all other equipment and materials specified shall be part of the work.

.2 All items of equipment and materials described in these specifications are to be furnished installed and placed into proper operating condition in accordance with good practice and manufacturer's written or published instructions.

- .1 The exhaust removal system shall provide virtually 100 percent complete evacuation of all diesel fumes at the source from start up to exit of the apparatus from the fire station. The diesel exhaust removal system shall be capable of delivering complete coverage for bays up to 120 feet (36.5 m) in length. The system must be able to accommodate drive through and back-in bays to meet all the needs of the fire department.
- .2 System must be designed and installed to NIOSH recommendation, specifying that occupational exposures to carcinogens be limited to the lowest feasible concentration. Exposure in the human breathing zone should be limited to lowest feasible level, without any time delay required for the system to effectively capture the diesel fumes.
- .3 System must also be capable to provide virtually complete capture and evacuation of carbon monoxide emitted as part of the vehicle exhaust.
- .4 Systems that solely use filters, in which diesel particulate may accumulate, and that would potentially have to be treated as hazardous materials, will not be accepted.
- .5 System must meet the guidelines for the International Mechanical Code for Source Capture Systems. Such system is defined as a mechanical exhaust system designed and constructed to capture air contaminants at their source and to exhaust such contaminants to the outdoor atmosphere.
- .6 The system shall not affect personnel boarding the apparatus. Hose loops shall not hang any lower than six feet from the bay floor. The hose assembly shall not come into contact with the vehicle other than one connection point to the vehicles tailpipe. The hose assembly shall not touch or drag on the bay floor.
- .7 The exhaust system shall not block doorways, exits, and aisles in the apparatus bay, which could endanger the welfare of fire personnel or visitors.
- .8 The exhaust system shall not need to be disconnected from the vehicle while shore lines are connected, during battery charging, or washing of the vehicle, as with other types of systems.
- .9 To protect the apparatus electrical system from possible damage, the system bid shall not incorporate any type of electromagnetic device that requires the apparatus to be utilized as an electrical ground for systems operation.
- .10 Due to the harmful effects of diesel exhaust, the system must be designed and capable of capturing virtually 100% of the exhaust gas and virtually 100% of the particulate even in the event of a complete power failure. The system shall not detach itself from the apparatus for any reason during a power failure other than normal exiting of the apparatus bay. System shall discharge exhaust outside the station even in the event of a power failure.
- .11 The system shall capture the exhaust gases and particulate directly from the tailpipe of the apparatus by a direct connected "visible" high temperature rated hose. Particulates emitted from the apparatus are known to be heavier than air and therefore must be captured by a directly connected hose with a tight seal, as loose nozzles or air filters cannot capture these heavy particulates. The particulates have been documented to be the main respirable carcinogen in diesel exhaust, and therefore are the primary concern of the fire department to capture virtually 100% of these particulates.

1.2 SUBMITTALS

.1 Product Data: Indicate manufacturer's model number, technical data including description of components and static pressure/air flow chart, and installation instructions.

.1 Details of wiring for power differentiating between manufacturer-installed and field-installed wiring.

.2 Closeout Submittals: Operation and Maintenance data manual including spare parts list.

1.3 QUALITY ASSURANCE

.1 Engage a factory certified installer to perform work of this Section who has completed installations similar in design and extent to that indicated for this Project, and who has a record of successful in-service performance. No Exceptions.

.2 The manufacturer must be a ISO 9001:2008 certified www.iso.org manufacturer with certification issued to a United States facility, this shows a commitment to delivering the highest quality service and products to the end user. Manufacturer shall be UL and CUL Certified www.ul.com/database/ and certified by the Air Movement and Control Association (AMCA) www.amca.org/search.htm to ensure quality, consistency and reliability of products. All certification documents shall be provided and attached to the bid proposal. No exceptions. Where the requirement calls for a packaged exhaust system to be provided, all items shall be the product of the manufacturer. The product offering must be a product that has been offered by that manufacturer for a minimum period of fifteen (15) years. No prototypes or private label products by other manufacturers will be allowed. System bid shall have a life of service of no less than 10 years to establish proof of quality, longevity and service. No exceptions.

.3 Engage a firm experienced in manufacturing vehicle exhaust systems similar to that indicated for this Project and with a record of successful in-service performance.

.4 Conduct conference at Project site. Review methods and procedures related to vehicle exhaust system installation.

.1 Review access requirements for equipment delivery.

.2 Review equipment storage and security requirements.

.3 Inspect condition of preparatory work performed by other trades.

.4 Review structural loading limitations.

.5 Review that all components specified in this Section and related components specified in other Sections are accounted for.

1.4 DELIVERY, STORAGE AND HANDLING

.1 Packing, Shipping, Handling and Unloading: Deliver components with protective packaging. Store in original protective crating and covering and in a dry location.

1.5 PROJECT/SITE CONDITIONS

.1 Existing Conditions: Verify dimensions installation areas by field measurements.

1.6 COORDINATION

.1 Coordinate layout and installation with other work, including light fixtures, fixed equipment and work stations, HVAC equipment, and fire-suppression system components.

.2 Coordinate location and requirements of service-utility connections.

1.7 REFERENCES

.1 Air Movement & Control Association International, Inc.

.1 AMCA Standard 500-D-98, "Laboratory Methods of Testing Dampers for Rating".

.2 ASTM International.

.1 Stainless Steel:

.1 A240/A240M-04ae1 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

.2 Bright, Directional Polish: No. 4 finish.

.3 Aluminum:

.1 B209/209M-04 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

.2 Powder-Coated Finish: Immediately after cleaning and pretreating, electrostatically apply manufacturer's standard baked-polymer thermosetting powder finish. Comply with resin manufacturer's written instructions for application, baking, and minimum dry film thickness.

.4 Galvanized Steel:

.1 A653/A653M-04a Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

1.8 BIDDER QUALIFICATIONS

.1 Bids will only be accepted from companies that have an established reputation in the business of system design, turnkey installation and long-term service of Automatic Emergency Response Vehicle Exhaust Removal Systems for a minimum of no less than five (5) years. Bidder shall be a registered corporation, partnership or sole proprietorship within the State where the installation is to take place. Bidder must have a current and valid state contractor's license, if required by the state for the work that is being bid. Bidder shall show proof that the system specified in this Bid Document has been field tested and proven by supplying a list of references with no less than 50 fire stations with systems installed by bidder (with comparable emergency and non-emergency run rates) within a 200 mile radius of municipality seeking bid. References shall be submitted with the Bid Document and shall include phone numbers and contact names.

1.9 MANUFACTURER QUALIFICATIONS

.1 Bids shall only be accepted by bidders supplying equipment from manufacturers that have an established reputation in the business of manufacturing Automatic Emergency Response Vehicle Exhaust Removal Systems for a minimum of no less than fifteen (15) years. The manufacturer must be a ISO 9001:2008 Certified in the United States www.iso.org, UL and CUL Certified www.ul.com/database/ and certified by the Air Movement and Control Association (AMCA) www.amca.org/search.htm to ensure quality, consistency and reliability of products. Certification documents shall be provided and attached to the bid proposal. No exceptions. Where the requirement calls for a packaged exhaust system to be provided, all items shall be the product of the manufacturer. The product offering must be a product that has been offered by that manufacturer for a minimum period of fifteen (15) years. No prototypes or private label products by other manufacturers will be allowed. System bid shall have a life of service of no less than 10 years to establish proof of quality, longevity and service. No exceptions.

1.10 SYSTEM OPERATION

.1 The auto-disconnect exhaust system shall be a 24-volt **electromagnetic** release type that captures 100% of the exhaust emissions directly from the tail pipe and discharges those emissions to a specific location by means of an exhaust fan. Upon emergency dispatch of the vehicle, the exhaust fan shall automatically start prior to the engine being energized. The exhaust fan shall remain in the "on" position for as long as any engine is running. Upon vehicle exit, the hose assembly remains connected to the tail pipe and automatically disconnects at a specified distance outside the door by de-energizing the electromagnet. The nozzle and hose assembly shall smoothly separate from the vehicle and safely retract to the stored position ready to connect to the vehicle upon reentry. Upon disconnection, the hose assembly shall not be permitted to swing wide or touch the floor, possibly endangering personnel or apparatus. The hose shall remain at the door, ready for reconnection. Once the apparatus has left the building, the fan will automatically shut down after a preset time interval. Upon return, the fan is automatically activated prior to vehicle entry and the nozzle is connected to the tail pipe in a standing position**. Bending over to connect the exhaust system and expose the operator to harmful exhaust fumes is not**

permitted. No positive locking device or moving parts shall be permitted to be connected to the tail pipe. After the vehicle has been turned off, the fan can continues to operate for a preset time interval, normally two minutes.

2 PRODUCTS

2.1 MANUFACTURERS

.1 Nederman.

2.2 SUCTION RAIL ASSEMBLY

.1 The Suction Rail shall be a polished aluminum extrusion that is formed in a configuration such that the extrusion serves not only as a suction duct, but also as the guide rail that the extraction trolley travels in. The wall thickness of the aluminum extrusion shall be no less than 2.381 mm (0.09375”). The weight of the aluminum extrusion is 6.8 kg/m (4.6 lbs. per lineal foot). The area of the aluminum extrusion, in a cross-sectional view, shall have the minimum equivalent area of 189 cm^2 (0.2035 sq. ft.) with an overall length as specified and indicated on the drawings. Each open end of the suction rail shall be covered with an end cap that can also be used as a round duct outlet for 15 cm (6”) diameter exhaust duct. As an alternate outlet, one or more rectangular-to-round transitions can be mounted on the topside of the suction rail after the cutout has been made per the manufacturer’s specified size. A pair of EPDM rubber seals is installed at the bottom of the extrusion opening. The rubber seals have a Teflon strip on the inside surface which enables the trolley to travel smoothly and unhindered. The rubber seals close tightly during fan operation for an airtight seal, but open evenly around the trolley during trolley travel. The suction rail shall be supplied with internal rubber bumpers installed at both ends that serve as secondary stops to the trolley. The suction rail shall be supplied with suspension attachments that are specifically designed for fastening to the configuration of the suction rail. Spacing of the suspension attachments shall not exceed 16 feet center-to-center.

2.3 EXTRACTION TROLLEY ASSEMBLY

.1 The Extraction Trolley Assembly serves as the component in the Rail System that travels in the suction rail, carries and supports the vertical hose assembly, balancer, current collectors, shock absorber and trolley stop mechanism. The Extraction Trolley body shall be made of light weight composite with a low friction surface on each side to enable the trolley to travel smooth through the rubber seal. Also, on a formed bracket mounted to the composite body, shall be a Disconnection box, acting as a circuit breaker for the Electro Magnet. The rail design must be capable of handling up to 4 vehicles parked in tandem.

2.4 BALANCER

.1 Integrated to the Extraction Trolley Assembly is a Balancer. The adjustable tension Balancer shall retract the hose and nozzle away from the vehicle as it leaves the building and safely suspend the assembly off the floor in the storage position when not in use. The Balancer shall have a spring characteristics that ensure that the cord is wound onto the drum at a safe and constant speed.

2.5 VERTICAL HOSE

.1 The Upper Vertical Suction Hose shall be 16 cm (6.2") in diameter, and of suitable flexibility to have a compression ratio of minimum 8:1. The hose material shall be Trevira fabric covered with HYPALON (CSM, Chloro-sulfonated polyethylene). The hose shall be fire resistant according to DIN 4102 B1. The lower hose shall be designed to withstand a 260° C (500° F) engine temperature in conjunction with induced ambient air for cooling. The hose shall be capable of withstanding temperatures of 171° C (340° F) continuously, up to 188° C (370° F) on an intermittent usage basis. (NOTE: If a ‘closed type sealed system’ is being used, the temperature ratings must be 360° C [680° F] and 393° C [740° F] respectively.) The helix shall be external and made of aluminum. The helix shall have high flexibility and the fabric able to withstand oil, chemical, ozone and weather resistance.

2.6 NOZZLE

.1 The Nozzle shall be a minimum of 20cm (8”) diameter and designed to capture 100% of the vehicle exhaust fumes generated at the vehicle tail pipe and is held in place by spring tension in conjunction with the electromagnet connection. The nozzle permits an ambient air mix in the air stream to immediately reduce exhaust emission temperatures up to 50% at the point of capture. The reduced air stream temperatures prolong component life by not permitting thermal breakdown of materials. The Nozzle shall be designed so as not to cause or create back pressure on any vehicle engine, nor draw raw diesel- or gasoline fumes into the exhaust hose while connected to a non-operating vehicle, nor create the possibility of spinning a non-lubricated turbo which could result in bearing failure.

.2 In a ‘closed type sealed system’, a pressurized container is created presenting an explosive potential when drawing raw fumes from a non-operating vehicle and all system electrical components must be of explosion proof design. **No closed system will be considered.** These conditions are non-existent with an ambient air mix nozzle design.

.3 The operator never has to touch the Nozzle for connection, but can position the Nozzle over the tail pipe while the operator grips the hose handle and simultaneously connects the electromagnet to the anchor plate. Tension will be automatically applied to the Nozzle created by an internal leaf spring assembly, which holds the Nozzle firmly in place over the tail pipe. The positioning of the electromagnet on the vehicle, combined with the tension created at the Nozzle, shall not allow the Nozzle to come away from the tail pipe until the electromagnet is either automatically or manually de-energized. The Nozzle shall be constructed of both metal and rubber, with no internal movable parts related to the connection of the Nozzle to the tail pipe. The Nozzle Hose shall be a minimum of 16 cm (6.2") in diameter. The hose material shall be lightweight coated fiberglass with a smooth bore. The galvanized steel helix shall be completely rubber covered. The inlet diameter at the Nozzle is oversized to allow maximum airflow capacity for large engines and/or pump tests. The inlet boot of the Nozzle is to be made of EPDM rubber, and bonded to a sturdy 24 gauge steel conical reducer. The design of the nozzle shall allow for maximum flexibility to accept a variety of tail pipe configurations, which typically terminate at 90° to the side of the vehicle. **Tail pipe adapters are not permitted nor required. No positive locking devices or a concept of a positive locking device, pneumatics, internal or external air hoses, wires, airbags, valves or precautionary devices for pneumatic bursting pressure, magnetic (earth magnet type) shall be permitted or allowed**.

2.7 ELECTROMAGNETIC ASSEMBLY

.1 **An electromagnet shall be used as the means of keeping the nozzle and hose assembly attached to the vehicle**, whether at rest or as it moves to the point of exit. The electromagnet shall be 24 volts, DC with power supplied via an insulated conductor encapsulated within the helix of the upper hose. The electromagnet assembly shall consist of a nitro carburized electromagnet disc, a manual override switch, and an anchor plate. The electromagnet disc assembly shall be slightly recessed to serve as a guide for ease of connection to the anchor plate mounted on the vehicle and serve as the energized contact point. The formed collar shall be of a smooth and rounded configuration to prevent hooking or catching on external devices of the vehicle.

.2 A manual override switch shall be easily accessible to disconnect the hose assembly while accessing storage compartments or performing vehicle maintenance. The manual override switch shall be conveniently mounted facing the operator. The purpose of the switch shall be to manually de-energize the electromagnet, allowing the hose and nozzle assembly to come away unrestrained from the vehicle when in the parked position within the building. The 24-volt UL switch shall be surrounded and mounted in a closed cell water resistant neoprene jacket.

.3 The Anchor Plate shall be mounted on the vehicle to allow the operator, in an upright position, to connect the electromagnet. The Anchor Plate shall have an outer circular isolated holder made of hard resilient plastic. Recessed in the center of the holder shall be a finished, Nedox treated steel disc to receive the electromagnet. The Anchor Plate shall be positioned on the vehicle in relation to the vertical and horizontal centerlines of the tail pipe outlet.

2.8 DISCONNECTION SWITCH

.1 Affixed to the Rail near the exit door, shall be a permanent magnet, which in conjunction with the disconnection box causes a 24-volt electromagnet to disconnect the hose assembly from the vehicle. The separation of the entire hose assembly from the vehicle is a one step process whereby no stress or strain is transferred from the vehicle to the exhaust hose or overhead brackets. Numerous mechanical functions to achieve nozzle separation such as valve activation, pneumatic deflation, and pulling forces to remove the nozzle from the tail pipe are not permitted. The disconnection switch shall be adjustable to create a nozzle release point at a specified distance as the vehicle exits the building. If a proper disconnect does not occur, the electromagnet has a built-in safety disconnection feature, which releases it with a 50-pound shear force. Then the hose and nozzle assembly remains intact. With other systems utilizing a mechanical or pneumatic direct connection to the tail pipe, a breakaway system is required to prevent the entire hose assembly from leaving the building with the vehicle.

2.9 END STOP

.1 The Rail shall be equipped with an End Stop, one for each Trolley, which is designed to stop the travel of the entire hose, nozzle, and balancer assembly. The stopping action itself must be spring cushioned to prevent the assembly from coming to an abrupt and immediate halt at an exit speed of up to 24 km/h (15 mph). The End Stop consists of a coiled spring hydraulic oil damper, which is located in the front end of the each Suction unit.

2.10 FAN AUTO-START

.1 The Fan Auto-Start serves to act as a remote control for fan start up to ensure the exhaust system is always running whenever an emergency vehicle is in operation. Upon dispatch, the exhaust fan shall automatically start and be running at full rpm prior to engine start up via a radio frequency transmitter mounted within the vehicle. The fan stays on as long as any vehicle is in operation. Upon vehicle exit or shut down, a variable timer then activates and the fan automatically turns off after a variable timed cycle. Upon vehicle return, the transmitter shall automatically activate the exhaust fan prior to the vehicle entering the building. The fan remains in operation until all vehicles are turned off and the timer then activates. The Control unit shall be FCC-approved and shall not interfere with radio communications garage doors or on board computers.

2.11 CENTRIFUGAL FANS

.1 The fan shall be a direct drive centrifugal type, high pressure, single width, single inlet as required or indicated. Impeller wheels shall be of a modified radial tip design, with top forward curve and airfoil thickness configuration characteristics. Impeller wheels shall be spark resistant and made of aluminum to prevent static electricity build up. The impeller shall be dynamically and static balanced, and of the non-overloading type to provide maximum efficiency while achieving quiet, vibrations free operation. The fan housing shall be manufactured from cast aluminum. The fan and motor assembly shall be mounted on a galvanized steel frame, which shall protect the motor, while also serving as a mounting platform for field installation.

.2 For fans 5 HP and larger, centrifugal fans shall be fully enclosed, single-width, single-inlet steel construction as required or indicated. Impeller wheels shall have backward inclined or backward curved blades of the non-overloading type. The bearings shall be self-aligned ball bearing type permanently sealed and lubricated. Fan shafts shall be steel and rotate in a non-sparking aluminum rubbing ring. Fans shall be accurately finished, and shall be provided with key and key seats for impeller hubs and fan pulleys. The fans shall be furnished with factory finish protective weather coating and a drain kit. The motor shall be totally enclosed fan cooled (TEFC). Motor starters shall be magnetic with general-purpose enclosures. The fan shall be structurally supported and provided with vibration isolators as specified to ensure quiet and smooth operation. The exhaust discharge outlet shall be in compliance with ACGIH recommendations and EPA requirements. Air intakes, windows, cascade systems, prevailing currents, communications equipment and building aesthetics will be considered in the final location of the fan. Exhaust filtration systems will be provided upon request and silencers will be provided when needed. All fans are tested in accordance with AMCA Standards in an AMCA approved test facility.

2.12 AIR FLOW PERFORMANCE

.1 Fan capacity shall be sized as such as to deliver a **650 cfm** (or as otherwise specified) at each hose drop to the vehicle being served. The exhaust system shall pull exhaust into the nozzle also inducing ambient air. The system shall be designed entirely for a negative pressure vacuum method of exhaust extraction. At no point in exhaust system will ducting be under positive pressure. Exhaust system hose drops shall be sized to maintain equal or larger cross sectional diameters than vehicle tailpipe. Exhaust systems, which do not size hose drops in accord with the vehicle engine capacity, as well as vehicle tailpipe diameter, shall not be accepted. The purpose of this portion of the specification is to insure that the exhaust system is designed to cool down exhaust as they are conveyed to the outside of fire station. This type of exhaust extraction keeps exhaust temperatures well below their designed temperature tolerances. This also prevents thermal break down of hose material thus adding years to system life. Exhaust systems that size exhaust drops without dilution ventilation and also down size the exhaust connection hose, unnecessarily put the vehicle engine warranty at risk. The delivered volume shall take into account all lengths of ductwork, elbows, and branches, shut off, wyes, etc., which accumulate the static pressure at the fan inlet. Manufacturer provided fans shall be performance guaranteed.

2.13 DUCTWORK SYSTEM

.1 Ducts, unless otherwise specified or approved, shall be round and conform to the dimensions as shown on the drawings. Ducts shall be straight and smooth on the inside with airtight joints. Wherever ducts are used with crimped ends, the joint shall have crimp and bead arrangement. The bead shall provide a rigid stop for the mating open end to seat. Ducts shall be constructed of galvanized steel and sealed in accordance with standard SMACNA methods, for the system designed negative pressure in inches w.g. All duct joints to sealed and air tight.

.2 Ductwork Type and Materials: UMC Class 2 or SMACNA Class II product conveying duct, meet or exceed criteria for construction and performance as outlined in Round Industrial Duct Construction Standards, SMACNA. Materials of construction unless otherwise specified for all ductwork and fittings shall be a minimum G-90 galvanized sheet metal (ASTM A653/A653M). Only when specified, Type 304 stainless steel (ASTM A240/A240M) shall be provided.

.3 Ductwork Sizing and Gauges: Round pipe construction, with the range of available sizes not to exceed 10 inches (254 mm) in diameter. Duct gauge shall depend on diameter and a minimum operating pressure of 8 inches water gauge (1990 Pa). Acceptable Gauge and Reinforcement Requirements: Inner duct diameter 4 inches (101.6 mm) through 11 inches (279.4 mm) diameter shall be 22 gauge standard pipe (International Mechanical Code).

.4 Ductwork Fittings: Round and have a wall thickness 2 gauges (one even gauge number) heavier than the lightest allowable gauge of the downstream section of duct to which they are connected (International Mechanical Code). Air Duct Branch Entrances: Factory fabricated fittings or factory fabricated duct /tap assemblies. Fittings: Constructed so that air streams converge at angles no greater than 45 degree (International Mechanical Code). All Seams: Continuous stitch welded and if necessary internally sealed to ensure air tightness. Turning elbows shall be stitch-welded and used for all diameters and pressures. They shall be fabricated of 24 gauge galvanized steel and constructed as two piece with continuous welded seam construction fittings similar to those provided by Lindab Inc. Tapered Body Fittings: Used wherever particular fallout is anticipated and where air flow is introduced to the transport duct manifold. Reducing fittings shall have a minimum of 2.54 cm (1") graduating increase in diameter per 20 cm (8") in length. Elbows up to 30 cm (12") in diameter shall have a centerline radius of not less than 1.5 times the diameter. Elbows beyond 30 cm (12") in diameter shall have a centerline radius of not less than 2.5 times the diameter. Branches shall enter the mains at a specified angle of not less than 30° with the centerline of the main duct in the direction of airflow, unless otherwise indicated or approved. Flexible connections to the main or branch duct shall be braced with approved metal straps or members.

.5 Where duct of dissimilar metals are connected, or where sheet metal connections are made to fan inlet and outlet, only an approved fireproof flexible connection shall be used. The connection shall be installed and securely fastened by zinc coated steel clinch type draw bands for round ducts.

.6 Ductwork Design Velocities: Minimum of 3500 FPM (20.3 M/Second) to 4000 FPM (23.2 M/Second) transport velocity. Capture Velocity: 5500 FPM (31.9 M/Second) to 6000 FPM (34.8 M/Second) to extract virtually 100 percent of the exhaust gases.

.7 External Ductwork: Sized for the exact inlet and outlet of the exhaust fan blower. An exhaust rain cap shall be supplied and manufactured in accordance with EPA standard for free draft rain cap requirements. Included as an integral part of this rain cap shall be a back draft damper to provide protection from rain and other inclement weather.

.8 Exhaust Penetrations: The core drilling shall be properly sized to reduce the diameter of the opening to the smallest possible size.

2.14 FRAMED OPENINGS AND DUCT SLEEVES

.1 Duct sleeves shall be provided for all round ducts ≤ 38 cm (15") diameter that pass through floors, walls, ceilings, or roofs. Sleeves in non-load bearing walls shall be fabricated of 20-gauge steel conforming to ASTM A 525. Sleeves in load bearing walls shall be fabricated of standard weight galvanized steel pipe conforming to ASTM A 53. Collars for round ducts ≤ 38 cm (15") " shall be fabricated from 20 gauge galvanized steel. Round ducts > 15" in diameter passing through floors, walls, ceilings, or roofs shall be installed through framed openings. Structural steel members for framed openings shall conform to ASTM A 36. Framed openings shall provide a 2.54 cm (1") clearance between the duct and the opening. A closure collar of galvanized steel ≥ 10 cm (4") wide shall be provided on each side of the walls or floors where sleeves or framed openings are provided.

2.15 STACKHEAD

.1 The exhaust discharge stack head will be a no loss type as recommended by ACGIH or as otherwise specified. The stack head design will protect against weather elements or introduction of debris.

2.16 DUCT TEST HOLES

.1 Test holes with covers shall be provided where indicated or directed, in the duct and plenum to insert Pitot tubes to take air measurements for balancing the air moving system if required.

3 EXECUTION

3.1 EXHAUST SYSTEM

.1 The exhaust removal system shall be installed as indicated and recommended by the manufacturer. Welding and brazing shall conform to ASME-17. Slip joints shall be sealed. Riser duct shall be supported to the structure as indicated on the drawings. Main duct shall be attached to building structural members.

3.2 BUILDING SURFACE PENETRATIONS

.1 All penetrations shall be sealed. Sleeves or framed openings shall be utilized where duct penetrates building surfaces. The space between the sleeve or framed opening and the duct shall be packed with mineral wool or approved material. Closure collars shall be installed around the duct on both sides of the penetrated surface. Collars shall fit tight against the building surfaces and snug around the duct.

3.3 GUIDE TRACK

.1 Installation height of Guide Track shall be between 3 m (10 ft.) to 4.6 m (16 ft.) range or as otherwise indicated on the drawings. The Guide Track shall be installed approximately 36 cm (14”) from the side of the vehicle and ≥ 30 cm (12”) away from the side edge of the exit door. The Guide Track for the exhaust system shall include corrosion resistant brackets for ease of mounting to structural channel, trusses, or angle iron. Brackets shall be a minimum of 0.318 cm (0.125") thickness. Mounting bolts to be no less than 0.953 cm (0.375") diameter (structural grade 8) for connection to steel frame. Bolts required for masonry installation shall be 0.5" x 3.5" expansion bolts, or 0.375" x 4" sleeve anchors for wall mount masonry connection.

.2 Recommendation: Unistrut 1 5/8” or Angle Iron 2”x 2”x 3/16”.

3.4 TESTS

.1 Each exhaust system and inlet shall be balanced to produce the indicated air quantities within 10 percent at the conditions shown. Any fans with bearings shall be lubricated, and the speed, direction and rotation of each fan shall be checked and verified as running correctly. The running current of each motor shall be checked and verified as correct. Upon completion and prior acceptance of the installation, the exhaust system shall be tested at the operating conditions to demonstrate satisfactory functional and operating efficiency. The Contractor shall provide all instruments, facilities, and labor required to properly conduct the tests.

3.5 EXAMINATION

.1 Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, service-utility connections, and other conditions affecting installation and performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.6 PREPARATION

.1 Provide surface/substrate preparation as required by the manufacturer's printed installation instructions. Do not proceed with installation is in proper condition to receive vehicle exhaust system installation.

3.7 INSTALLATION

.1 Install vehicle exhaust system in accord with manufacturer's written instructions, original design and referenced standards.

3.8 ADJUSTING

.1 Adjust vehicle exhaust system for proper operation. Replace any parts that prevent the system from operating properly.

3.9 CLEANING

.1 Remove all debris caused by installation of the vehicle exhaust system. Clean all exposed surfaces to as fabricated condition and appearance.

3.10 PROTECTION

.1 Provide protection of the completed installation until completion of the project. Repair any damage at no additional cost to Owner.

3.11 TRAINING

.1 Provide training to fire department personnel in the daily use and maintenance of the vehicle exhaust removal system that has been installed and specified herein. The fire department shall be notified at least 7 days prior to the date scheduled for the training course. Training shall be for all personnel involved with the operation of the exhaust removal system to include all shifts required to man the particular facility. The Training session shall be performed in person by a recognized representative of the manufacturer of the exhaust removal system, in addition a training video shall be provided to the fire department.

.1 Provide training to all shifts during their normal shift period.

3.12 WARRANTY

.1 Provide a written warranty for a period of 1 year from date of shipment for all components.

END OF SECTION

1 GENERAL

1.1 SUBMITTALS

.1 Provide submittals in accordance with Division 01.

.2 Product Data:

.1 Provide manufacturer's printed product literature and datasheets for inlets, hoses, ducts, and fans, and include product characteristics, performance criteria, physical size, finish and limitations.

.3 Shop Drawings.

.1 Indicate following:

.1 Fan performance curves.

.2 Filtering details.

.3 Control details.

.4 Installation details.

1.2 CLOSEOUT SUBMITTALS

.1 Provide operation and maintenance data for incorporation into O&M manual.

1.3 MAINTENANCE MATERIAL SUBMITTALS

.1 Submit list of manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.

1.4 DELIVERY, STORAGE, AND HANDLING

.1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.

2 Products

2.1 DIESEL EXHAUST CAPTURE SYSTEM

.1 General

.1 Provide where shown on Drawing Airmation Diesel exhaust capture units. The air filtration units and activation systems shall work together to eliminate, capture, reduce the vehicle exhaust produced by apparatus in addition to contaminants generated from other sources. Sources of apparatus bay contamination may consist of airborne engine vapors, apparatus leaking seals, diesel and gas exhaust, soot, gases, carbon monoxide, nitrous dioxide, turn-out gear out gassing, power saw or any other on board emergency gasoline or diesel powered equipment. The system must be capable of the capture of intermittent exhaust migration due to apparatus or other internal combustion equipment being run on the facility tarmac or apron. Additional toxins to be captured must include Volatile Organic Compounds (VOCs), particulate, and lung damaging dust.

.2 System

.1 The air filtration system must be a totally automatic activated system that also contains a manual override system. It must be hands free, to allow emergency personnel to respond to the emergency at hand. The system must automatically activate when bay doors open, when apparatus egress and ingress the fire station or by means of several other optional means, as stated within this specification. The filtration system must operate for a minimum of twenty (20) minutes to complete station air cleaning. The system must have the capability to increase this time to a maximum of 9 hours on an initial activation.

.2 Additional manual override switches must allow for each individual unit to operate on a 24/7 basis as deemed necessary by the end user; initiate all units to operate on a predetermined set time; a reset to bypass the timer and terminate activation with a cascading down of units as they turn off. The timer control should allow for selective units to run in continuous low speed operation (700cfm), while still maintaining high speed operation (2700 – 2800cfm) when bay door are activated for vehicle entry/exit.

.3 The timer control must be designed to sequentially start and stop the exhaust capture air filtration units to avoid power surges and contain only UL/CSA approved components. The timer control box must be 100% low voltage (24V max.) to eliminate shock hazards to personnel.

.3 Test Data

.1 The system must have documented evidence of having been successfully tested to meet regulatory health and safety standards in no less than two different active Fire / EMS departments. Each test to be conducted by a different qualified independent environmental engineering firm. One of the submitted test results must show, with NO EXCEPTIONS, as a matter of personnel health and safety, that the system meets and/or surpasses federal regulatory standards for ACGIH, NFPA, BOCA4, ASHRAE3, EPA, OSHA, PEL (short term), TLV/STEL, and NIOSH. Test parameters must include VOCs, NO2, SO2, CO, Particulates and Diesel Exhaust Particulates as one of the standards of measurement. The testing must have been performed by a certified Industrial Hygienist and must verify performance standards with fire apparatus idling in bays, on the tarmac, and entering/exiting bays as would occur during normal station operation.

.4 Equipment

.1 The filtration system shall be delivered and installed as a turnkey project with no requirement for station personnel involvement. The exhaust capture equipment will be of a self-contained three stage progressive filtration designed system. The system filtration media must be verified by the manufacturer to be capable of capturing vehicle exhaust with a blower and with a motor capable of a delivered volume of 2700 cfm (cubic feet per minute) meeting NFPA and OSHA Standards. Clean, filtered air must be returned to the apparatus bay areas from the rear of the same system. The system must not contain a catalytic oxidizer so as to eliminate/avoid excess water and carbon dioxide by-products within apparatus bays.

.5 Equipment Features

.1 The following features and capabilities must exist as part of the system:

.1 Ceiling suspended design evenly distributing unit weight

.2 115V or 230V power with no less than a 3000 cfm blower driven by 1 hp single phase ECM 6 speed motor 4.7 amps. *note an ECM motor is up to 75% more energy efficient than a standard blower motor, providing significant energy cost savings.

.3 Utilization of horizontal pull-through design for optimum exhaust elimination

.4 Dual V-Bank 99% DOP, MERV 16a (rated for 3000cfm), and Gas Phase carbon blended with alumina 50/50

.5 Relocation or re-positioning capabilities, not a permanent fixture type system

.6 Access internally sealed filter replacement compartment door from either side of the unit utilizing two (2) swell latch handles to ensure safety in filter access and replacement

.7 Compartment door with swell latch handles, no bolts, to open on the door for safety in height access and expediency in filter replacement

.8 Rear LED filter change indicator to be visible from the floor level and at the control Panel

.9 Visible breaker switch light

.10 Capability of 24/7 operation

.11 Maximum 60 db sound level when in operation, adjustable to 50 dba at low speed.

.12 Front directional grille intake direction must force the entering exhaust into the filtration media

.13 Filter access door must be adjustable to either left or right side to ensure proper service clearance and allow for proper location of units without compromise.

.14 Units with no intake louvers are unacceptable due to lack of directional filtration intake

.15 Must have rear baffle box to exhaust clean air back into bay areas through a minimum of more than 300 directional ports so as to evenly distribute return clean air and provide a fan sound control system for apparatus bay areas. Adjustable direction louver, so that the air flow pattern can be adjusted to fix the work space and properly mix air.

.6 Equipment Activation

.1 The air filtration system must work in tandem with and include an automatic, hands free, activation system featuring:

.2 Operation engineered through a wall mount Timer Control Maintenance Monitor (TCSMM)

.1 Completely low voltage (24 VAC max) for personnel safety

.2 No maintenance will be required over the entire life of the system

.3 Housed in a NEMA1 enclosure complying with UL and CSA specifications

.4 TCSMM must have 3-speed program capability.

.5 TCSMM to contain a 90 minute/ 9 hour timer adjustable to operate in 10 minute increments from 10-90 minutes, and 1 hour to 9 hours.

.6 TCSMM switches to allow individual unit manual bypass opting for 24/7 operation.

.7 TCSMM must be capable of running at continuous low speed operation and auto kick into high speed mode on demand.

.8 TCSMM to have an external timer bypass switch for immediate system shutdown. System to automatically reactivate under any normal activation inputs.

.9 A photoelectric-eye to span up to 200 contiguous feet of bay doors and be able to operate at least 7' off the floor. Doors not in-line with other doors or having obstructions with over 4' of wall or barrier protrusions eliminating a clear line of site will require a separate photoelectric-eye beam.

.10 Emergency Shutdown Circuit, to shut down system in the event of a fire.

.11 Filter change lights.

.12 Allows for remote activation switches.

.13 4 individual zone inputs. Used to isolate front door activation/ rear door activation / gas phase sensor activation, etc.

.14 Additional Auxiliary input for future activation modes, such and chronographic timer, etc.

.15 System off switch. This turns off system to prevent activation, for time of building maintenance such as painting, drywall etc. Or system maintenance while changing filters.

.16 Door opening, closing, apparatus egress or ingress must activate all units within the apparatus bays.

.17 TCSMM MUST have the capability to accommodate up to sixteen filtration units per control unit, for future system expansion

.18 System must have automatic shut down and restart if station has a fire alarm within the bays.

.19 Be able to accept up to three alternate methods of activation including 1) Response to the station's tone alert, 2) Apparatus ignition activation, Kussmaul MODEL # 091133 or equivalent, 3) Activation in response to signal from CO/NO2 monitor utilizing Vulcain Model VA301M or equivalent.

.7 Equipment Safety

.1 Station personnel safety being a top priority, the system will include the following safety features:

.1 All TCSMM control wiring shall be low voltage (24VAC max) to eliminate electrical hazard.

.2 TCSMM will house internal visible LED indicators for all ON units.

.3 All components must be UL/CSA registered.

.4 Filtration units must have an integral overload breaker switch to work in tandem with electrical panel breakers.

.5 Filtration unit blower and wiring to be contained in a single blower box compartment, inaccessible to personnel.

.6 TCSMM must have an input to disable all filtration units during a building fire alarm and then return the filtration units to normal operation after the alarm situation is resolved or turned off.

.7 System must be capable of cycling down or up when turned on or off to avoid power surges

.8 Filter tracks to ensure safe filter replacement.

.9 System must not house a catalytic converter to avoid excess carbon dioxide and water by products in the bay areas.

.10 Factory secured seismic restraint connection hardware.

.8 Equipment Filters

.1 The filters are a critical component of the system and MUST comply with the following criteria. All filtration media must be separately housed in a self contained compartment with sealing on the filter door to avoid gas/particulate bypass, tight fit, slide track, filter compartment to eliminate diesel and contaminant bypass of the individual filters. Each filter must be have its own rail. The filter door closure must contain seals to avoid bypass air. Pre-filter for normal fire station use, last 18month to 24 months.

.1 Pre-Filter panel:

.1 Must be capable of providing a minimum efficiency reporting value of MERV 8a when evaluated under the guideline of ASHRAE Std. 52.2.19.

.1 Placement follows the front directional louver grille and fits snugly within a track.

.2 To be no less than 24" x 24" x 4" (nominal), including frame, incorporating filtration media of no less than 26.6 ft^2.

.3 Initial resistance must be .25 using 22 radial pleats.

.4 Air flow capacity at 300 fpm must be 1200.

.5 Air flow capacity at 500 fpm must be 2000 @ .25.

.6 Filter frame must be composed of moisture resistant heavy duty beverage board frame.

.7 Must have two piece frame construction with double wall thickness around the outer edge and integral die cut cross member.

.8 Pleats must have individual die cut fingers.

.9 The adhesive used must be highly water repellent and cover the entire inside of the die cut frame.

.10 Pleats supports must be composed of galvanized steel.

.11 Shall be classified by Underwriters Laboratories as UL Class 2.

.12 Designed to perform up to 18-24 months and longer, based on environmental conditions and use. Typically 24 month for normal fire station use.

.2 High Efficiency Particle Filter Second Stage:

.1 NO LESS than 99% DOP MERV 16a ASHRAE rating, V-bank formation DOP design to encompass a minimum surface area of 200 ft2 and capable of removing particulate as small as 0.3µ in size. 5 Star Energy Rated.

.2 Be enclosed in a heavy-duty, moisture resistant die cut frame to eliminate warping, cracking, or distortion under normal operation conditions.

.3 Integral pleat separators to provide pleat stabilization. Must not contain any aluminum or steel separators in between filter strata of each V-Bank section.

.4 Effective at 100% relative humidity, turbulent air flow, intermittent exposure to water and repeated fan shutdowns.

.5 Air flow resistance at 500 fpm must be .80.

.6 Must be rated to work from 0°F to 180°F.

.7 Must be able to handle air flow volumes up to 3000 cfm.

.8 Perimeter header must be secured by standard latches or clamping devices.

.9 Must be leak free around the entire perimeter of the filter.

.10 Each mini-pleat pack must be sealed within the heat resistant plastic end panels and galvanized steel support struts.

.11 Mini-pleats are to be separated by continuous beads of thermo-setting adhesive, not steel separators between mini-pleats.

.12 Must measure no less than 24" x 24" x 12" (nominal), including frame and fit snugly into the track.

.13 Cannot be a flat face filter to avoid intense filter blockage.

.14 Virtually all lung damaging diesel particulate to be captured.

.15 Shall be classified by Underwriters Laboratories as UL 900 Class 2.

.16 Designed to perform up to 24-48 months and longer, based on environmental conditions and use.

.3 Gas Phase Carbon/Alumina Filter:

.1 Must contain a minimum of 26 lbs. of carbon blend with alumina, to include 50% active premium grade coconut shell carbon with 50% active alumina.

.2 Filter frame weight to be separately calculated.

.3 To measure no less than 24" x 24" x 12" (nominal), including filter frame.

.4 Must have V-bank design, not flat face surface, to provide extensive capture, extended life and fit snugly into the track.

.5 Must have galvanized steel support struts on both sides of the filter.

.6 End caps must be made from resilient ABS plastic.

.7 The honeycomb panels containing the carbon granules must be water resistant

.8 Non-volatile hot melt glue must be used to bond the carbon panels, end caps and steel support members.

.9 Initial resistance at 500 fpm must be .38" w.g.

.10 Cannot show evidence of air pockets between absorbent carbon/alumina.

.11 The gas phase filter must be capable of controlling and eliminating VOCs, chemicals and gas of diesel contamination within the apparatus bays.

.12 Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

.13 Designed to perform for up to 24-48 months to longer, depending on environmental conditions and use.

.4 Automatic Roll Filter:

.1 Shall act as a preliminary filter, capable of capturing and containing particulate in the 8-10μ size.

.2 Filter face must measure as a minimum 40" x 40" and provide a 600' flat sheet polyester REEMAY roll.

.3 To advance based on air pressure measured by a photohelic gauge.

.4 The photohelic gauge automatically controls the indexing motor for filter advance. As the air pressure drops, the photohelic gauge stops the indexing motor.

.5 The motor and controls to be 120 VAC and a separate power circuit and fuse must be provided to power all of the circuits.

.6 All wiring and components to be UL approved.

.7 Designed to perform for up to 5-6 years or longer, depending on environmental conditions and use.

.5 Automatic Activation Equipment:

.1 The vendor to provide automatic activation options for the purchaser selection.

.1 Carbon Monoxide/Nitrogen Dioxide (CO/NO2) Activation:

.2 The Vulcain Model VA301M, or equivalent, shall be integrated into the system for additional safety operation. The CO/NO2 monitor must be connected to the TCSMM to engage the air filtration units automatically once the gas detector measures unsafe levels of CO and/or NO2 in the apparatus bays. The air filtration units are to operate until these gases are reduced to OSHA acceptable levels. These are two separate monitor sensors. The CO monitor will be installed 5" off the floor. The NO2 monitor sensor will be installed a minimum of 5' below the ceiling.

.3 Ignition Activation.

.9 Warranty

.1 Include a warranty of at least two (2) years on all system parts and labor, excluding filters. Warranty can be voided when equipment is damaged by customer’s negligence or misuse. The warranty will remain in effect only when installations and repairs are performed by a qualified licensed electrician who is contracted by the equipment vendor.

.10 Alternate Equipment

.1 Manegrip

.2 ACS

.3 or Approved Equivalent

2.2 MANUFACTURERS

.1 Airmation.

.2 No substitutions.

3 Execution

3.1 APPLICATION

.1 Manufacturer's Instructions: comply with manufacturer's written recommendations, including product technical bulletins, handling, storage and installation instructions, and datasheets.

3.2 INSTALLATION

.1 Provide vehicle exhaust removal system.

.2 Install in accordance with NFPA 91, and to manufacturers instructions.

.3 Make joints watertight and airtight when subjected to 1.5 kPa pressure.

.4 Install duct supports to manufacturer's recommendations.

.5 Install unit above the exhaust of truck.

.6 Coordinate final location with truck locations and fire station team.

.7 Provide all necessary accessories and parts required for complete installation.

.8 Provide door sensor for activating the unit.

.9 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls for Mechanical Equipment.

.10 Coordinate power wiring connection and provision of a disconnect switch for each ventilator in accordance with electrical work Specification where power wiring is specified.

.11 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.12 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

3.3 TESTING

.1 Test units with the manufacturer. Provide testing report.

3.4 CLEANING

.1 Clean in accordance system and filters prior to start.

3.5 DEMONSTRATION AND TRAINING

.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 SUMMARY

.1 Provide all labour, materials, and equipment necessary to put in working operation a complete turnkey system to remove both diesel and automotive exhaust gases and particulate of operating vehicles within the confines of specified fire station(s). All necessary controls, motors, fittings, ductwork, blower(s), labor and all other equipment and materials specified shall be part of the work.

.2 All items of equipment and materials described in these specifications are to be furnished installed and placed into proper operating condition in accordance with good practice and manufacturer’s written or published instructions.

.1 The exhaust removal system shall provide virtually 100 percent complete evacuation of all diesel fumes at the source from start up to exit of the apparatus from the fire station. The diesel exhaust removal system shall be capable of delivering complete coverage for bays up to 120 feet (36.5 m) in length. The system must be able to accommodate drive through and back-in bays to meet all the needs of the fire department.

.2 System must be designed and installed to NIOSH recommendation, specifying that occupational exposures to carcinogens be limited to the lowest feasible concentration. Exposure in the human breathing zone should be limited to lowest feasible level, without any time delay required for the system to effectively capture the diesel fumes.

.3 System must also be capable to provide virtually complete capture and evacuation of carbon monoxide emitted as part of the vehicle exhaust.

.4 Systems that solely use filters, in which diesel particulate may accumulate, and that would potentially have to be treated as hazardous materials, will not be accepted.

.5 System must meet the guidelines for the International Mechanical Code for Source Capture Systems. Such system is defined as a mechanical exhaust system designed and constructed to capture air contaminants at their source and to exhaust such contaminants to the outdoor atmosphere.

.6 The system shall not affect personnel boarding the apparatus. Hose loops shall not hang any lower than six feet from the bay floor. The hose assembly shall not come into contact with the vehicle other than one connection point to the vehicles tailpipe. The hose assembly shall not touch or drag on the bay floor.

.7 The exhaust system shall not block doorways, exits, and aisles in the apparatus bay, which could endanger the welfare of fire personnel or visitors.

.8 The exhaust system shall not need to be disconnected from the vehicle while shore lines are connected, during battery charging, or washing of the vehicle, as with other types of systems.

.9 To protect the apparatus electrical system from possible damage, the system bid shall not incorporate any type of electromagnetic device that requires the apparatus to be utilized as an electrical ground for systems operation.

.10 Due to the harmful effects of diesel exhaust, the system must be designed and capable of capturing virtually 100% of the exhaust gas and virtually 100% of the particulate even in the event of a complete power failure. The system shall not detach itself from the apparatus for any reason during a power failure other than normal exiting of the apparatus bay. System shall discharge exhaust outside the station even in the event of a power failure.

.11 The system shall capture the exhaust gases and particulate directly from the tailpipe of the apparatus by a direct connected “visible” high temperature rated hose. Particulates emitted from the apparatus are known to be heavier than air and therefore must be captured by a directly connected hose with a tight seal, as loose nozzles or air filters cannot capture these heavy particulates. The particulates have been documented to be the main respirable carcinogen in diesel exhaust, and therefore are the primary concern of the fire department to capture virtually 100% of these particulates.

1.2 SUBMITTALS

.1 Product Data: Indicate manufacturer's model number, technical data including description of components and static pressure/air flow chart, and installation instructions.

.1 Details of wiring for power differentiating between manufacturer-installed and field-installed wiring.

.2 Closeout Submittals: Operation and Maintenance data manual including spare parts list.

1.3 QUALITY ASSURANCE

.1 Engage a factory certified installer to perform work of this Section who has completed installations similar in design and extent to that indicated for this Project, and who has a record of successful in-service performance. No Exceptions.

.2 The manufacturer must be a ISO 9001:2008 certified www.iso.org manufacturer with certification issued to a United States facility, this shows a commitment to delivering the highest quality service and products to the end user. Manufacturer shall be UL and CUL Certified www.ul.com/database/ and certified by the Air Movement and Control Association (AMCA) www.amca.org/search.htm to ensure quality, consistency and reliability of products. All certification documents shall be provided and attached to the bid proposal. No exceptions. Where the requirement calls for a packaged exhaust system to be provided, all items shall be the product of the manufacturer. The product offering must be a product that has been offered by that manufacturer for a minimum period of fifteen (15) years. No prototypes or private label products by other manufacturers will be allowed. System bid shall have a life of service of no less than 10 years to establish proof of quality, longevity and service. No exceptions.

.3 Engage a firm experienced in manufacturing vehicle exhaust systems similar to that indicated for this Project and with a record of successful in-service performance.

.4 Conduct conference at Project site. Review methods and procedures related to vehicle exhaust system installation.

.1 Review access requirements for equipment delivery.

.2 Review equipment storage and security requirements.

.3 Inspect condition of preparatory work performed by other trades.

.4 Review structural loading limitations.

.5 Review that all components specified in this Section and related components specified in other Sections are accounted for.

1.4 DELIVERY, STORAGE AND HANDLING

.1 Packing, Shipping, Handling and Unloading: Deliver components with protective packaging. Store in original protective crating and covering and in a dry location.

1.5 PROJECT/SITE CONDITIONS

.1 Existing Conditions: Verify dimensions installation areas by field measurements.

1.6 COORDINATION

.1 Coordinate layout and installation with other work, including light fixtures, fixed equipment and work stations, HVAC equipment, and fire-suppression system components.

.2 Coordinate location and requirements of service-utility connections.

1.7 REFERENCES

.1 Air Movement & Control Association International, Inc.

.1 AMCA Standard 500-D-98, "Laboratory Methods of Testing Dampers for Rating".

.2 ASTM International.

.1 Stainless Steel:

.1 A240/A240M-04ae1 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

.2 Bright, Directional Polish: No. 4 finish.

.3 Aluminum:

.1 B209/209M-04 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

.2 Powder-Coated Finish: Immediately after cleaning and pretreating, electrostatically apply manufacturer's standard baked-polymer thermosetting powder finish. Comply with resin manufacturer's written instructions for application, baking, and minimum dry film thickness.

.4 Galvanized Steel:

.1 A653/A653M-04a Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

1.8 BIDDER QUALIFICATIONS

.1 Bids will only be accepted from companies that have an established reputation in the business of system design, turnkey installation and long-term service of Automatic Emergency Response Vehicle Exhaust Removal Systems for a minimum of no less than five (5) years. Bidder shall be a registered corporation, partnership or sole proprietorship within the State where the installation is to take place. Bidder must have a current and valid state contractor’s license, if required by the state for the work that is being bid. Bidder shall show proof that the system specified in this Bid Document has been field tested and proven by supplying a list of references with no less than 50 fire stations with systems installed by bidder (with comparable emergency and non-emergency run rates) within a 200 mile radius of municipality seeking bid. References shall be submitted with the Bid Document and shall include phone numbers and contact names.

1.9 MANUFACTURER QUALIFICATIONS

.1 Bids shall only be accepted by bidders supplying equipment from manufacturers that have an established reputation in the business of manufacturing Automatic Emergency Response Vehicle Exhaust Removal Systems for a minimum of no less than fifteen (15) years. The manufacturer must be a ISO 9001:2008 Certified in the United States www.iso.org, UL and CUL Certified www.ul.com/database/ and certified by the Air Movement and Control Association (AMCA) www.amca.org/search.htm to ensure quality, consistency and reliability of products. Certification documents shall be provided and attached to the bid proposal. No exceptions. Where the requirement calls for a packaged exhaust system to be provided, all items shall be the product of the manufacturer. The product offering must be a product that has been offered by that manufacturer for a minimum period of fifteen (15) years. No prototypes or private label products by other manufacturers will be allowed. System bid shall have a life of service of no less than 10 years to establish proof of quality, longevity and service. No exceptions.

1.10 SYSTEM OPERATION

.1 The auto-disconnect exhaust system shall be a 24-volt **electromagnetic** release type that captures 100% of the exhaust emissions directly from the tail pipe and discharges those emissions to a specific location by means of an exhaust fan. Upon emergency dispatch of the vehicle, the exhaust fan shall automatically start prior to the engine being energized. The exhaust fan shall remain in the “on” position for as long as any engine is running. Upon vehicle exit, the hose assembly remains connected to the tail pipe and automatically disconnects at a specified distance outside the door by de-energizing the electromagnet. The nozzle and hose assembly shall smoothly separate from the vehicle and safely retract to the stored position ready to connect to the vehicle upon reentry. Upon disconnection, the hose assembly shall not be permitted to swing wide or touch the floor, possibly endangering personnel or apparatus. The hose shall remain at the door, ready for reconnection. Once the apparatus has left the building, the fan will automatically shut down after a preset time interval. Upon return, the fan is automatically activated prior to vehicle entry and the nozzle is connected to the tail pipe in a standing position**. Bending over to connect the exhaust system and expose the operator to harmful exhaust fumes is not**

permitted. No positive locking device or moving parts shall be permitted to be connected to the tail pipe. After the vehicle has been turned off, the fan can continues to operate for a preset time interval, normally two minutes.

2 PRODUCTS

2.1 MANUFACTURERS

.1 Nederman.

2.2 SUCTION RAIL ASSEMBLY

.1 The Suction Rail shall be a polished aluminum extrusion that is formed in a configuration such that the extrusion serves not only as a suction duct, but also as the guide rail that the extraction trolley travels in. The wall thickness of the aluminum extrusion shall be no less than 2.381 mm (0.09375”). The weight of the aluminum extrusion is 6.8 kg/m (4.6 lbs. per lineal foot). The area of the aluminum extrusion, in a cross-sectional view, shall have the minimum equivalent area of 189 cm^2 (0.2035 sq. ft.) with an overall length as specified and indicated on the drawings. Each open end of the suction rail shall be covered with an end cap that can also be used as a round duct outlet for 15 cm (6”) diameter exhaust duct. As an alternate outlet, one or more rectangular-to-round transitions can be mounted on the topside of the suction rail after the cutout has been made per the manufacturer’s specified size. A pair of EPDM rubber seals is installed at the bottom of the extrusion opening. The rubber seals have a Teflon strip on the inside surface which enables the trolley to travel smoothly and unhindered. The rubber seals close tightly during fan operation for an airtight seal, but open evenly around the trolley during trolley travel. The suction rail shall be supplied with internal rubber bumpers installed at both ends that serve as secondary stops to the trolley. The suction rail shall be supplied with suspension attachments that are specifically designed for fastening to the configuration of the suction rail. Spacing of the suspension attachments shall not exceed 16 feet center-to-center.

2.3 EXTRACTION TROLLEY ASSEMBLY

.1 The Extraction Trolley Assembly serves as the component in the Rail System that travels in the suction rail, carries and supports the vertical hose assembly, balancer, current collectors, shock absorber and trolley stop mechanism. The Extraction Trolley body shall be made of light weight composite with a low friction surface on each side to enable the trolley to travel smooth through the rubber seal. Also, on a formed bracket mounted to the composite body, shall be a Disconnection box, acting as a circuit breaker for the Electro Magnet. The rail design must be capable of handling up to 4 vehicles parked in tandem.

2.4 BALANCER

.1 Integrated to the Extraction Trolley Assembly is a Balancer. The adjustable tension Balancer shall retract the hose and nozzle away from the vehicle as it leaves the building and safely suspend the assembly off the floor in the storage position when not in use. The Balancer shall have a spring characteristics that ensure that the cord is wound onto the drum at a safe and constant speed.

2.5 VERTICAL HOSE

.1 The Upper Vertical Suction Hose shall be 16 cm (6.2") in diameter, and of suitable flexibility to have a compression ratio of minimum 8:1. The hose material shall be Trevira fabric covered with HYPALON (CSM, Chloro-sulfonated polyethylene). The hose shall be fire resistant according to DIN 4102 B1. The lower hose shall be designed to withstand a 260° C (500° F) engine temperature in conjunction with induced ambient air for cooling. The hose shall be capable of withstanding temperatures of 171° C (340° F) continuously, up to 188° C (370° F) on an intermittent usage basis. (NOTE: If a ‘closed type sealed system’ is being used, the temperature ratings must be 360° C [680° F] and 393° C [740° F] respectively.) The helix shall be external and made of aluminum. The helix shall have high flexibility and the fabric able to withstand oil, chemical, ozone and weather resistance.

2.6 NOZZLE

.1 The Nozzle shall be a minimum of 20cm (8”) diameter and designed to capture 100% of the vehicle exhaust fumes generated at the vehicle tail pipe and is held in place by spring tension in conjunction with the electromagnet connection. The nozzle permits an ambient air mix in the air stream to immediately reduce exhaust emission temperatures up to 50% at the point of capture. The reduced air stream temperatures prolong component life by not permitting thermal breakdown of materials. The Nozzle shall be designed so as not to cause or create back pressure on any vehicle engine, nor draw raw diesel- or gasoline fumes into the exhaust hose while connected to a non-operating vehicle, nor create the possibility of spinning a non-lubricated turbo which could result in bearing failure.

.2 In a 'closed type sealed system', a pressurized container is created presenting an explosive potential when drawing raw fumes from a non-operating vehicle and all system electrical components must be of explosion proof design. **No closed system will be considered.** These conditions are non-existent with an ambient air mix nozzle design.

.3 The operator never has to touch the Nozzle for connection, but can position the Nozzle over the tail pipe while the operator grips the hose handle and simultaneously connects the electromagnet to the anchor plate. Tension will be automatically applied to the Nozzle created by an internal leaf spring assembly, which holds the Nozzle firmly in place over the tail pipe. The positioning of the electromagnet on the vehicle, combined with the tension created at the Nozzle, shall not allow the Nozzle to come away from the tail pipe until the electromagnet is either automatically or manually de-energized. The Nozzle shall be constructed of both metal and rubber, with no internal movable parts related to the connection of the Nozzle to the tail pipe. The Nozzle Hose shall be a minimum of 16 cm (6.2") in diameter. The hose material shall be lightweight coated fiberglass with a smooth bore. The galvanized steel helix shall be completely rubber covered. The inlet diameter at the Nozzle is oversized to allow maximum airflow capacity for large engines and/or pump tests. The inlet boot of the Nozzle is to be made of EPDM rubber, and bonded to a sturdy 24 gauge steel conical reducer. The design of the nozzle shall allow for maximum flexibility to accept a variety of tail pipe configurations, which typically terminate at 90° to the side of the vehicle. **Tail pipe adapters are not permitted nor required. No positive locking devices or a concept of a positive locking device, pneumatics, internal or external air hoses, wires, airbags, valves or precautionary devices for pneumatic bursting pressure, magnetic (earth magnet type) shall be permitted or allowed**.

2.7 ELECTROMAGNETIC ASSEMBLY

.1 **An electromagnet shall be used as the means of keeping the nozzle and hose assembly attached to the vehicle**, whether at rest or as it moves to the point of exit. The electromagnet shall be 24 volts, DC with power supplied via an insulated conductor encapsulated within the helix of the upper hose. The electromagnet assembly shall consist of a nitro carburized electromagnet disc, a manual override switch, and an anchor plate. The electromagnet disc assembly shall be slightly recessed to serve as a guide for ease of connection to the anchor plate mounted on the vehicle and serve as the energized contact point. The formed collar shall be of a smooth and rounded configuration to prevent hooking or catching on external devices of the vehicle.

.2 A manual override switch shall be easily accessible to disconnect the hose assembly while accessing storage compartments or performing vehicle maintenance. The manual override switch shall be conveniently mounted facing the operator. The purpose of the switch shall be to manually de-energize the electromagnet, allowing the hose and nozzle assembly to come away unrestrained from the vehicle when in the parked position within the building. The 24-volt UL switch shall be surrounded and mounted in a closed cell water resistant neoprene jacket.

.3 The Anchor Plate shall be mounted on the vehicle to allow the operator, in an upright position, to connect the electromagnet. The Anchor Plate shall have an outer circular isolated holder made of hard resilient plastic. Recessed in the center of the holder shall be a finished, Nedox treated steel disc to receive the electromagnet. The Anchor Plate shall be positioned on the vehicle in relation to the vertical and horizontal centerlines of the tail pipe outlet.

2.8 DISCONNECTION SWITCH

.1 Affixed to the Rail near the exit door, shall be a permanent magnet, which in conjunction with the disconnection box causes a 24-volt electromagnet to disconnect the hose assembly from the vehicle. The separation of the entire hose assembly from the vehicle is a one step process whereby no stress or strain is transferred from the vehicle to the exhaust hose or overhead brackets. Numerous mechanical functions to achieve nozzle separation such as valve activation, pneumatic deflation, and pulling forces to remove the nozzle from the tail pipe are not permitted. The disconnection switch shall be adjustable to create a nozzle release point at a specified distance as the vehicle exits the building. If a proper disconnect does not occur, the electromagnet has a built-in safety disconnection feature, which releases it with a 50-pound shear force. Then the hose and nozzle assembly remains intact. With other systems utilizing a mechanical or pneumatic direct connection to the tail pipe, a breakaway system is required to prevent the entire hose assembly from leaving the building with the vehicle.

2.9 END STOP

.1 The Rail shall be equipped with an End Stop, one for each Trolley, which is designed to stop the travel of the entire hose, nozzle, and balancer assembly. The stopping action itself must be spring cushioned to prevent the assembly from coming to an abrupt and immediate halt at an exit speed of up to 24 km/h (15 mph). The End Stop consists of a coiled spring hydraulic oil damper, which is located in the front end of the each Suction unit.

2.10 FAN AUTO-START

.1 The Fan Auto-Start serves to act as a remote control for fan start up to ensure the exhaust system is always running whenever an emergency vehicle is in operation. Upon dispatch, the exhaust fan shall automatically start and be running at full rpm prior to engine start up via a radio frequency transmitter mounted within the vehicle. The fan stays on as long as any vehicle is in operation. Upon vehicle exit or shut down, a variable timer then activates and the fan automatically turns off after a variable timed cycle. Upon vehicle return, the transmitter shall automatically activate the exhaust fan prior to the vehicle entering the building. The fan remains in operation until all vehicles are turned off and the timer then activates. The Control unit shall be FCC-approved and shall not interfere with radio communications garage doors or on board computers.

2.11 CENTRIFUGAL FANS

.1 The fan shall be a direct drive centrifugal type, high pressure, single width, single inlet as required or indicated. Impeller wheels shall be of a modified radial tip design, with top forward curve and airfoil thickness configuration characteristics. Impeller wheels shall be spark resistant and made of aluminum to prevent static electricity build up. The impeller shall be dynamically and static balanced, and of the non-overloading type to provide maximum efficiency while achieving quiet, vibrations free operation. The fan housing shall be manufactured from cast aluminum. The fan and motor assembly shall be mounted on a galvanized steel frame, which shall protect the motor, while also serving as a mounting platform for field installation.

.2 For fans 5 HP and larger, centrifugal fans shall be fully enclosed, single-width, single-inlet steel construction as required or indicated. Impeller wheels shall have backward inclined or backward curved blades of the non-overloading type. The bearings shall be self-aligned ball bearing type permanently sealed and lubricated. Fan shafts shall be steel and rotate in a non-sparking aluminum rubbing ring. Fans shall be accurately finished, and shall be provided with key and key seats for impeller hubs and fan pulleys. The fans shall be furnished with factory finish protective weather coating and a drain kit. The motor shall be totally enclosed fan cooled (TEFC). Motor starters shall be magnetic with general-purpose enclosures. The fan shall be structurally supported and provided with vibration isolators as specified to ensure quiet and smooth operation. The exhaust discharge outlet shall be in compliance with ACGIH recommendations and EPA requirements. Air intakes, windows, cascade systems, prevailing currents, communications equipment and building aesthetics will be considered in the final location of the fan. Exhaust filtration systems will be provided upon request and silencers will be provided when needed. All fans are tested in accordance with AMCA Standards in an AMCA approved test facility.

2.12 AIR FLOW PERFORMANCE

.1 Fan capacity shall be sized as such as to deliver a **650 cfm** (or as otherwise specified) at each hose drop to the vehicle being served. The exhaust system shall pull exhaust into the nozzle also inducing ambient air. The system shall be designed entirely for a negative pressure vacuum method of exhaust extraction. At no point in exhaust system will ducting be under positive pressure. Exhaust system hose drops shall be sized to maintain equal or larger cross sectional diameters than vehicle tailpipe. Exhaust systems, which do not size hose drops in accord with the vehicle engine capacity, as well as vehicle tailpipe diameter, shall not be accepted. The purpose of this portion of the specification is to insure that the exhaust system is designed to cool down exhaust as they are conveyed to the outside of fire station. This type of exhaust extraction keeps exhaust temperatures well below their designed temperature tolerances. This also prevents thermal break down of hose material thus adding years to system life. Exhaust systems that size exhaust drops without dilution ventilation and also down size the exhaust connection hose, unnecessarily put the vehicle engine warranty at risk. The delivered volume shall take into account all lengths of ductwork, elbows, and branches, shut off, wyes, etc., which accumulate the static pressure at the fan inlet. Manufacturer provided fans shall be performance guaranteed.

2.13 DUCTWORK SYSTEM

.1 Ducts, unless otherwise specified or approved, shall be round and conform to the dimensions as shown on the drawings. Ducts shall be straight and smooth on the inside with airtight joints. Wherever ducts are used with crimped ends, the joint shall have crimp and bead arrangement. The bead shall provide a rigid stop for the mating open end to seat. Ducts shall be constructed of galvanized steel and sealed in accordance with standard SMACNA methods, for the system designed negative pressure in inches w.g. All duct joints to sealed and air tight.

.2 Ductwork Type and Materials: UMC Class 2 or SMACNA Class II product conveying duct, meet or exceed criteria for construction and performance as outlined in Round Industrial Duct Construction Standards, SMACNA. Materials of construction unless otherwise specified for all ductwork and fittings shall be a minimum G-90 galvanized sheet metal (ASTM A653/A653M). Only when specified, Type 304 stainless steel (ASTM A240/A240M) shall be provided.

.3 Ductwork Sizing and Gauges: Round pipe construction, with the range of available sizes not to exceed 10 inches (254 mm) in diameter. Duct gauge shall depend on diameter and a minimum operating pressure of 8 inches water gauge (1990 Pa). Acceptable Gauge and Reinforcement Requirements: Inner duct diameter 4 inches (101.6 mm) through 11 inches (279.4 mm) diameter shall be 22 gauge standard pipe (International Mechanical Code).

.4 Ductwork Fittings: Round and have a wall thickness 2 gauges (one even gauge number) heavier than the lightest allowable gauge of the downstream section of duct to which they are connected (International Mechanical Code). Air Duct Branch Entrances: Factory fabricated fittings or factory fabricated duct /tap assemblies. Fittings: Constructed so that air streams converge at angles no greater than 45 degree (International Mechanical Code). All Seams: Continuous stitch welded and if necessary internally sealed to ensure air tightness. Turning elbows shall be stitch-welded and used for all diameters and pressures. They shall be fabricated of 24 gauge galvanized steel and constructed as two piece with continuous welded seam construction fittings similar to those provided by Lindab Inc. Tapered Body Fittings: Used wherever particular fallout is anticipated and where air flow is introduced to the transport duct manifold. Reducing fittings shall have a minimum of 2.54 cm (1") graduating increase in diameter per 20 cm (8") in length. Elbows up to 30 cm (12") in diameter shall have a centerline radius of not less than 1.5 times the diameter. Elbows beyond 30 cm (12") in diameter shall have a centerline radius of not less than 2.5 times the diameter. Branches shall enter the mains at a specified angle of not less than 30° with the centerline of the main duct in the direction of airflow, unless otherwise indicated or approved. Flexible connections to the main or branch duct shall be braced with approved metal straps or members.

.5 Where duct of dissimilar metals are connected, or where sheet metal connections are made to fan inlet and outlet, only an approved fireproof flexible connection shall be used. The connection shall be installed and securely fastened by zinc coated steel clinch type draw bands for round ducts.

.6 Ductwork Design Velocities: Minimum of 3500 FPM (20.3 M/Second) to 4000 FPM (23.2 M/Second) transport velocity. Capture Velocity: 5500 FPM (31.9 M/Second) to 6000 FPM (34.8 M/Second) to extract virtually 100 percent of the exhaust gases.

.7 External Ductwork: Sized for the exact inlet and outlet of the exhaust fan blower. An exhaust rain cap shall be supplied and manufactured in accordance with EPA standard for free draft rain cap requirements. Included as an integral part of this rain cap shall be a back draft damper to provide protection from rain and other inclement weather.

.8 Exhaust Penetrations: The core drilling shall be properly sized to reduce the diameter of the opening to the smallest possible size.

2.14 FRAMED OPENINGS AND DUCT SLEEVES

.1 Duct sleeves shall be provided for all round ducts ≤ 38 cm (15") diameter that pass through floors, walls, ceilings, or roofs. Sleeves in non-load bearing walls shall be fabricated of 20-gauge steel conforming to ASTM A 525. Sleeves in load bearing walls shall be fabricated of standard weight galvanized steel pipe conforming to ASTM A 53. Collars for round ducts ≤ 38 cm (15") " shall be fabricated from 20 gauge galvanized steel. Round ducts > 15" in diameter passing through floors, walls, ceilings, or roofs shall be installed through framed openings. Structural steel members for framed openings shall conform to ASTM A 36. Framed openings shall provide a 2.54 cm (1") clearance between the duct and the opening. A closure collar of galvanized steel ≥ 10 cm (4") wide shall be provided on each side of the walls or floors where sleeves or framed openings are provided.

2.15 STACKHEAD

.1 The exhaust discharge stack head will be a no loss type as recommended by ACGIH or as otherwise specified. The stack head design will protect against weather elements or introduction of debris.

2.16 DUCT TEST HOLES

.1 Test holes with covers shall be provided where indicated or directed, in the duct and plenum to insert Pitot tubes to take air measurements for balancing the air moving system if required.

3 EXECUTION

3.1 EXHAUST SYSTEM

.1 The exhaust removal system shall be installed as indicated and recommended by the manufacturer. Welding and brazing shall conform to ASME-17. Slip joints shall be sealed. Riser duct shall be supported to the structure as indicated on the drawings. Main duct shall be attached to building structural members.

3.2 BUILDING SURFACE PENETRATIONS

.1 All penetrations shall be sealed. Sleeves or framed openings shall be utilized where duct penetrates building surfaces. The space between the sleeve or framed opening and the duct shall be packed with mineral wool or approved material. Closure collars shall be installed around the duct on both sides of the penetrated surface. Collars shall fit tight against the building surfaces and snug around the duct.

3.3 GUIDE TRACK

.1 Installation height of Guide Track shall be between 3 m (10 ft.) to 4.6 m (16 ft.) range or as otherwise indicated on the drawings. The Guide Track shall be installed approximately 36 cm (14”) from the side of the vehicle and ≥ 30 cm (12”) away from the side edge of the exit door. The Guide Track for the exhaust system shall include corrosion resistant brackets for ease of mounting to structural channel, trusses, or angle iron. Brackets shall be a minimum of 0.318 cm (0.125") thickness. Mounting bolts to be no less than 0.953 cm (0.375") diameter (structural grade 8) for connection to steel frame. Bolts required for masonry installation shall be 0.5" x 3.5" expansion bolts, or 0.375" x 4" sleeve anchors for wall mount masonry connection.

.2 Recommendation: Unistrut 1 5/8” or Angle Iron 2”x 2”x 3/16”.

3.4 TESTS

.1 Each exhaust system and inlet shall be balanced to produce the indicated air quantities within 10 percent at the conditions shown. Any fans with bearings shall be lubricated, and the speed, direction and rotation of each fan shall be checked and verified as running correctly. The running current of each motor shall be checked and verified as correct. Upon completion and prior acceptance of the installation, the exhaust system shall be tested at the operating conditions to demonstrate satisfactory functional and operating efficiency. The Contractor shall provide all instruments, facilities, and labor required to properly conduct the tests.

3.5 EXAMINATION

.1 Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, service-utility connections, and other conditions affecting installation and performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.6 PREPARATION

.1 Provide surface/substrate preparation as required by the manufacturer's printed installation instructions. Do not proceed with installation is in proper condition to receive vehicle exhaust system installation.

3.7 INSTALLATION

.1 Install vehicle exhaust system in accord with manufacturer's written instructions, original design and referenced standards.

3.8 ADJUSTING

.1 Adjust vehicle exhaust system for proper operation. Replace any parts that prevent the system from operating properly.

3.9 CLEANING

.1 Remove all debris caused by installation of the vehicle exhaust system. Clean all exposed surfaces to as fabricated condition and appearance.

3.10 PROTECTION

.1 Provide protection of the completed installation until completion of the project. Repair any damage at no additional cost to Owner.

3.11 TRAINING

.1 Provide training to fire department personnel in the daily use and maintenance of the vehicle exhaust removal system that has been installed and specified herein. The fire department shall be notified at least 7 days prior to the date scheduled for the training course. Training shall be for all personnel involved with the operation of the exhaust removal system to include all shifts required to man the particular facility. The Training session shall be performed in person by a recognized representative of the manufacturer of the exhaust removal system, in addition a training video shall be provided to the fire department.

    .1 Provide training to all shifts during their normal shift period.

3.12 WARRANTY

.1 Provide a written warranty for a period of 1 year from date of shipment for all components.

END OF SECTION

1 General

1.1 SUBMITTALS

.1 Submit shop drawings/product data sheets for each hood and accessories. Include following:

- .1 certified power and control wiring schematics;
- .2 product data for all accessories;
- .3 drawings indicating methods of assembly and installation details.

.2 Submit with delivery of each hood a copy of the factory inspection report, and include a copy of the report with O & M Manual project close-out data.

.3 Submit site inspection and start-up reports from manufacturer's representative as specified in Part 3 of this section.

.4 Submit documentation from a third party testing laboratory to certify hood to be supplied has been tested and is listed as being in accordance with requirements of NSF/ANSI No. 2.

.5 Hand to Owner, at Substantial Performance of the Work, an identified filter removal tool.

1.2 QUALITY ASSURANCE

.1 Kitchen cooking equipment exhaust hood is to be constructed and certified in accordance with requirements of governing Provincial/Municipal Regulations, and following standards:

- .1 UL 300, Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment;
- .2 UL 710, Exhaust Hoods for Commercial Cooking Equipment;
- .3 UL 1046, Grease Filters for Exhaust Ducts;
- .4 NSF/ANSI No. 2, Food Equipment, including listing and approval by a third part testing laboratory;
- .5 NFPA 17/17A, Standard for Dry/Wet Chemical Fire Extinguishing Systems;
- .6 NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

.2 Each hood is to be installed by personnel experienced in installation of food service equipment, using licensed journeyman plumbers and electricians to connect electrical and plumbing services to hood.

.3 Hood manufacturer/supplier is to have an exhaust hood parts and 24/7 service facility within 100 km of site.

.4 Acceptable manufacturers must meet all requirements of this section and drawing details/requirements.

2 Products

2.1 KITCHEN COOKING EQUIPMENT EXHAUST HOOD

.1 CSA certified and labelled, completely enclosed, water-tight Type I grease and smoke extractor exhaust hood with manufacturer, model number, size, and configuration as indicated on drawings, constructed of minimum #20 gauge type 304 stainless steel with a #4 brushed satin finish on all exposed surfaces. Hood designed to permit thorough cleaning of entire hood and to automatically start exhaust fan, and constructed using continuous welded standing seam method with all exposed external welds ground and polished to the specified hood finish. Hood is to be complete with:

- .1 hot-dipped galvanized steel framework;
- .2 grease extractor type, high efficiency cartridge style baffle filters of adequate number and size to ensure optimum performance, arranged to be easily accessible and removable for cleaning (with a filter removal tool supplied loose) so all exhaust air will pass through filters, installed at an angle not less than 45° from horizontal with housing terminating in a pitched, full length grease trough which is to drain into a removable minimum 3.78 L (1 gal) capacity container;

.3 vapour-proof, recessed fluorescent lighting fixtures with energy efficient ballasts and T-8 WWRS lamps for a minimum of 540 lux (50 f.c.) illumination at cooking surface, pre-wired in accordance with Code requirements to a junction box located at top of the hood;

.4 self-closing, accessible, stainless steel ULC listed and labelled fire damper with fusible link(s) in the duct connection collar, and a pressurized wet chemical fire detection and suppression system with hood fusible link(s), suppression chemical cylinder assembly with wall mounting bracket, a manual pull station, and a surface wall mounting control panel with #4 finish stainless steel hinged enclosure and all required controls and contacts for interconnection to exhaust fan and source of heat supply to cooking equipment, fire alarm system, and, if applicable, building automation system;

.5 factory secured seismic restraint connection hardware.

.6 A double wall insulated front to eliminate condensation and increase rigidity. The insulation shall have a flexural modulus of 475 EI, meet UL 181 requirements and be in accordance with NFPA 90A and 90B.

.7 An integral front baffle to direct grease laden vapors toward the exhaust filter bank.

.8 A built-in wiring chase provided for outlets and electrical controls on the hood face and shall not penetrate the capture area or require an external chaseway.

.9 Removable grease cup for easy cleaning.

3 Execution

3.1 INSTALLATION OF KITCHEN EXHAUST HOOD FOR COOKING EQUIPMENT

.1 Provide an exhaust hood over kitchen cooking equipment.

.2 Install hood level and plumb with access clearances required for operation, maintenance, and cleaning, and in accordance with manufacturer’s instructions. Coordinate installation with building structural support facilities.

.3 Install components supplied loose with hood. Perform required fire suppression system and domestic water and drain piping in accordance with requirements of Contract Documents.

.4 Perform required control wiring in conduit in accordance with certified control wiring schematics and requirements of the electrical work wiring requirements. Carefully coordinate all control wiring such that following sequences occur:

.1 with control panel selector switch turned to "RUN", exhaust fan is energized and return air damper is closed;

.2 with control panel selector switch turned to "WASH", exhaust and make-up air fans are de-energized, wash cycle begins after a 60 second delay, and ends after a pre-set time (3 minutes);

.3 when a fire condition occurs with fans not operating, exhaust fan continues to operate, make-up air fan is de-energized, wash down cycle is disabled, and dry contacts of the fire relay re-close;

.4 when a fire condition occurs with fans operating, exhaust fan automatically starts, make-up air fan remains de-energized, wash down cycle stops or is disabled, and dry contacts of the fire relay re-close.

.5 Brace and secure each unit in accordance with requirements specified in Section 20 05 00 - Seismic Controls for Mechanical Systems.

.6 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements. Hood manufacturer/supplier is to visit site at 25%, 50%, and 100% installation intervals and after each visit, is to issue an installation certification report.

.7 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements. Prior to start-up, under supervision of hood manufacturer’s technical representative and with all required jurisdictional authorities present, perform a complete test to demonstrate proper operation of all hood functions and sequences.

3.2 DEMONSTRATION AND TRAINING

.1 Include for two, 6 hour on-site operation demonstration and training sessions for two groups of six 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 SUBMITTALS

.1 Submit product data sheets for flue gas vents/air intakes and accessories.

.2 Supply a reviewed shop drawing to appropriate trade to indicate vent size and flashing materials supplied, and accurately locate building openings.

2 Products

2.1 CONDENSING APPLIANCE TYPE BH FLUE GAS VENTS (AND COMBUSTION AIR INTAKES)

.1 Equal to Ipex "System 636" PVC (for vent gas to 65°C [130°F]) or CPVC (for vent gas to 90°C [195°F]) solvent weld vent pipe and fittings, in accordance with CAN/CSA B149.1, certified as type BH vents to ULC S636, Standard for Type BH Gas Venting Systems, suitable for negative or positive venting and complete with an orange warning label to verify compliance with ULC S636, and a moulded cap with screen for vertical termination, or low profile wall termination kit, as applicable.

2.2 DOUBLE WALL STAINLESS STEEL VENT FOR CONDENSING EQUIPMENT

.1 Positive pressure double wall stainless steel flue gas vent with a type 304 outer casing, an AL29-4C inner flue, and a 25 mm (1") annular air space, ULC S636 listed and labelled, complete with prefabricated mated fittings and accessories including a flashing accessory, storm collar counter-flashing piece, and a termination cap.

3 Execution

3.1 INSTALLATION OF FLUE GAS VENTS

.1 Provide ULC listed and labelled flue gas vents for equipment. Confirm flue gas vent diameters prior to ordering.

.2 Support spacing is to be in accordance with flue gas vent manufacturer’s instructions. Installation is to be in accordance with gas fired appliance manufacturer’s instructions and requirements of CAN/CSA B149.1.

.3 Route piping using shortest route possible to termination point while avoiding interference with other work. Slope vent piping for positive drainage.

.4 Secure horizontal sections in place by means of support hardware supplied with vents and conforming to flue diameter, and hanger rods attached to structure. Support spacing is to be in accordance with vent manufacturer’s instructions.

.5 Support vertical flue sections inside building at roof level and wherever else required by means of purpose made vertical support accessories supplied by manufacturer.

.6 Hand flashing collars to roofing trade at site on roof for installation and flashing into roof construction. Install counter-flashing pieces over collars.

.7 Equip termination of each chimney with a rain cap. Confirm height requirement for chimney above roof prior to installation, and ensure proper distance from fresh air intakes is maintained.

.8 Anchor and restrain vents in accordance with requirements of Section 20 05 48.16 - Seismic Controls for Mechanical Systems.

.9 Provide required accessories, including insulated thimbles at building wall penetrations, barometric damper(s), cleanout(s), fire stops, and expansion joints where shown and/or required.

.10 Locate and install barometric dampers in accordance with manufacturer’s instructions and field adjust to suit operating conditions.

End of Section

1 General

1.1 RELATED REQUIREMENTS

.1 Section 23 51 23 – Gas Vents.

1.2 SUBMITTALS

.1 Submit shop drawings/product data sheets for radiant heaters, including accessories, control, and power and control wiring schematics.

.2 Submit with delivery of heaters, copies of the factory inspection report, and include a copy of each report with O & M Manual project close-out data.

.3 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this section.

.4 Submit signed copies of radiant heater manufacturer's extended warranties as follows:

.1 heater controls: 3 years;

.2 combustion chamber and radiant tubes: 7 years.

.5 Submit a signed copy of unit heater manufacturer's 15 year extended warranty for stainless steel heat exchanger of each unit heater.

.6 Install one unit heater (mechanically and electrically) in a location selected by Consultant. Operate heater at full fire to demonstrate specified air throw. Supply all required measurement instruments. If air throw is not as specified, modify or change unit heater discharge nozzle to obtain specified results. Do not install remainder of heaters until mock-up has been accepted.

1.3 QUALITY ASSURANCE

.1 Heaters and installation of heaters are to be in accordance with requirements of following:

.1 all applicable Provincial Codes and Standards;

.2 CAN/CSA-B149.1, Natural Gas and Propane Installation Codes.

.2 Heater installation tradesmen are to be journeyman tradesmen licensed to install gas fired equipment.

2 Products

2.1 GAS FIRED UNIT HEATERS

.1 CSA or cETL certified condensing horizontal air flow unit heaters, each factory assembled, pre-rewired, and test fired, each in accordance with drawing schedule, and with characteristics as follows:

.1 noise: not to exceed 75 dBA at 1 m (3');

.2 efficiency: minimum steady state thermal efficiency of 93% in accordance with ASHRAE 90.1;

.3 electrical supply: 120 volts, 1-phase, 60 Hz;

.4 gas supply: between 1.7 and 3.5 kPa (0.25 and 0.50 psi);

.5 venting: horizontal or vertical.

.2 Internally insulated cabinet constructed of heavy-gauge galvanized steel, finished with baked powder epoxy enamel, and complete with hinged access door, adjustable louvers, a wiring junction box mounted inside or on exterior of cabinet, mounting spot nuts for hanger rods secured to top of cabinet, or an accessory mounting bracket kit.

.3 Tubular, curved design 409 stainless steel heat exchanger, secured to a vest panel equipped with flue box and a motorized combustion air inducer to purge heat exchanger and positively vent combustion products, and aluminized steel inshot burners, each removable from assembly or all removable as a single component, and complete with a venturi to mix gas and air for proper combustion, and a burner view port. Secondary heat exchanger made of AL29-4® stainless steel and complete with a 10-year warranty.

.4 Direct driven propeller type fan(s), depending on unit size, with permanently lubricated open drip-proof motor(s) conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical, and a wire cage guard.

.5 Factory installed and pre-wired controls and safeties complete with:

.1 24 volt redundant combination gas valve with 100% safety shut-off, manual main shut-off valve, pressure regulator, and automatic solenoid valve;

.2 solid-state, electronic, direct spark ignition and a separate electronic flame sensor to initiate 3 attempts to re-ignite after loss of flame, then locks out unit operation;

.3 pressure switch to prove adequate flow through venting;

.4 high temperature limit controls with a fixed temperature setting to protect from abnormal operating temperatures;

.5 solid-state, integrated, combination ignition and fan control board with fan timer control, diagnostic LED for trouble shooting, and continuous fan operation control;

.6 120/24 volt control transformer;

.7 terminal strip for 24 volt control connections;

.8 all required hardware to interface unit heater control with building automation system in accordance with drawing control sequence and points list.

.9 Energy Saver Controls – as the temperature increases, gas to be disabled and stratified ceiling air circulated to heat the space until ceiling air temperature decreases below setpoint.

.6 Contractor Convenience Package featuring a condensate pump convenience outlet, unit on/off switch, heater function status indicator lights, and external terminals for thermostat wiring

.7 Heavy-gauge galvanized steel discharge nozzles selected by heater manufacturer to achieve scheduled air flow, finished to match cabinets.

.8 Seismic restraint anchors factory secured to heaters.

.9 Acceptable manufacturers are:

.1 Modine

.2 Beacon-Morris;

.3 Thomas & Betts Corp. "Reznor";

.4 Sterling HVAC Products.

3 Execution

3.1 INSTALLATION OF GAS FIRED UNIT HEATERS

.1 Provide gas fired unit heaters.

.2 Secure unit heaters in place at proper height by means of hanger rods attached to structure. Ensure heaters are level and plumb. Provide any supplemental structural steel necessary for installation where shown. Ensure unit discharge is not obstructed.

.3 Brace and restrain each unit heater in accordance with requirements of Section 20 05 48.16 - Seismic Controls for Mechanical Systems.

.4 Ensure air throw from each heater conforms to air throw of approved mock-up.

.5 Connect with valved gas piping with drip leg. Use a length of flexible gas piping with 360° loop for final connection.

.6 Provide a maximum of 1.5 m (5') of single wall stainless steel horizontal vent between unit heater and flue. Provide flues in accordance with requirements of Section 23 51 23 - Gas Vents.

.7 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.8 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

3.2 DEMONSTRATION AND TRAINING

.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 Heat Recovery Ventilators

1.2 SUBMITTALS

.1 Submit shop drawings/product data sheets for heat recovery ventilators, including accessories, and all required power and control wiring schematics.

.2 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.

.3 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this section.

.4 Supply a spare filter set for each ventilator and store at site where directed prior to Substantial Performance of the Work.

.5 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.

.6 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.

1.3 QUALITY ASSURANCE

.1 Heat 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 ANSI/AMCA Standard 210, Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating;
- .2 AMCA Standard 211, Product Rating Manual for Fan Air Performance;
- .3 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans;
- .4 AMCA Standard 311, Product Rating Manual for Fan Sound Performance;
- .5 AMCA Standard 99-2408, Operating Limits for Centrifugal Fans;
- .6 AHRI Standard 1060, Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment;
- .7 ASHRAE 84, Method of Testing Air-to-Air Heat/Energy Exchangers;
- .8 UL 1812, Ducted Heat Recovery Ventilators;
- .9 CSA or ETL certification for all electrical components.

.2 Acceptable manufacturers are:

- .1 Cook;
- .2 Greenheck Fan Corp.;
- .3 Venmar CES Inc.;
- .4 Summeraire Manufacturing;
- .5 Carrier Corp;
- .6 Daikin;
- .7 Aldes.

2 Products

2.1 DEDICATED OUTSIDE AIR SYSTEMS

.1 Factory assembled, internally wired heat recovery ventilators in accordance with drawing schedule, and with AHRI certified energy recovery ratings.

.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./ft.³) 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:

- .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 removable gasketed panels or hinged gasketed access doors provided for access to all interior components;
- .3 stainless steel drain pan pitched for positive drainage and equipped with captive condensate drain pipe connection.

.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./ft.³) 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:

- .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 removable gasketed panels or hinged gasketed access doors provided for access to all interior components;
- .3 stainless steel drain pan pitched for positive drainage and equipped with captive condensate drain pipe connection;
- .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;
- .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.

.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:

- .1 silica gel desiccant permanently bonded to lightweight polymer media mounted in a stainless steel rotor;
- .2 bearings selected for a minimum L-10 life in excess of 400,000 hours;
- .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;

.4 frost control protection with an electric pre-heater.

.5 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.

.6 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:

.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 motors and where indicated, belt drives conforming to requirements specified in Section 20 05 00 – Common Work Results for Mechanical.

.7 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.

.8 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.

.9 Factory supplied, mounted, and wired variable frequency drives conforming to requirements of Section 20 05 13.13 - Variable Frequency Drives for Mechanical Equipment.

.10 Electric Preheat coils in accordance with drawing schedule, each certified in accordance with CSA C22.2 No. 155, Electric Duct Heaters and CAN/CSA C22.2 No. 236, Heating and Cooling Equipment, and each complete with frame members, terminal boxes and covers and associated sheet metal work constructed of heavy-gauge die-formed steel with an integral corrosion-resistant coating and fabricated into coil shape by spot welding, a corrosion protected sheathed heating element, an automatic reset and an auxiliary manual reset snap-action high temperature limit control to protect coils from overheating from any cause, and a pre-wired control panel for electrical power and control connections.

.1 Each control panel is to be complete with:

.1 disconnect switch;

.2 magnetic contactor(s);

.3 terminal blocks for power and control wiring connections;

.4 pre-wired differential pressure switch to shut-down coil upon sensing a "no-airflow" condition;

.5 fused control transformer;

.6 electronic step controller to suit the number of heating stages;

.11 Factory secured seismic restraint connection hardware.

3 Execution

3.1 INSTALLATION

.1 Provide heat recovery ventilators.

.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 Secure each indoor floor mounted ventilator in place, level and plumb, on neoprene-steel-neoprene vibration isolation pads on a concrete housekeeping pad.

.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.

.5 Brace and secure each unit in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls for Mechanical Equipment.

.6 Coordinate power wiring connection and provision of a disconnect switch for each ventilator in accordance with electrical work Specification where power wiring is specified.

.7 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.8 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

3.2 DEMONSTRATION AND TRAINING

.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

1.1 SUBMITTALS

.1 Submit shop drawings/product data sheets for all make-up air units. Include following:

.1 certified fan performance curves;

.2 certified sound power data;

.3 hardware for section-to-section site connections;

.4 dimensioned layouts, including dimensioned curb layouts as applicable;

.5 product data for fan motors.

.2 Submit with delivery of each furnace a copy of the factory inspection and fire test report as specified in Part 2 of this section, and include a copy of each report with O & M Manual project close-out data.

.3 Submit a site inspection and start-up report from manufacturer’s representative as specified in Part 3 of this section.

.4 Submit spare air filters as specified in Part 2 of this section.

1.2 QUALITY ASSURANCE

.1 Make-up air units and installation are to be in accordance with requirements of following:

.1 all applicable Provincial Codes and Standards;

.2 CAN/CSA B149, Natural Gas and Propane Installation Codes;

.3 CSA or cETL listed and labelled electrical components.

.2 Make-up air unit installation tradesmen are to be journeyman and licensed gas fitters.

.3 Acceptable manufacturers are:

.1 CaptiveAire;

.2 En Mar Systems Ltd.;

.3 Greenheck Fan Corp.;

.4 Trane Canada Corp.;

.5 Mestek Inc. Sterling;

.6 Engineered Air;

.7 Thomas & Betts Reznor.

2 Products

2.1 GAS FIRED MAKE-UP AIR UNITS

.1 Description: An Indirect-fired gas heating and ventilating unit(s), as indicated on the drawings shall be furnished. Orientation shall be Horizontal (Down) (Side) (Up) discharge. Unit(s) shall be factory assembled, tested and shipped as a complete packaged assembly, for indoor or outdoor mounting, consisting of the following:

.1 gas furnace;

.2 centrifugal blower (forward-curved double width/double inlet or backwards inclined);

.3 motor starter with thermal overload protection;

.4 motor and drive assembly;

.5 fuel burning and safety equipment;

.6 temperature control system, and

.7 gas piping.

.8 Pre-piped and charged condenser(s)

.2 Down discharge, air-tight, weather-proof make-up air units, approved for operation in ambient temperatures of -50°C (-60°F), in accordance with drawing schedule and details, factory inspected and fire tested with an inspection and fire test report prepared and submitted, and following additional performance features:

.1 units are to be suitable for operation at any supply gas pressure between 1.7 kPa and 3.5 kPa (0.25 psi and 0.51 psi);

.2 unless otherwise specified, sound emitted through casings or intakes of roof mounted units at maximum air flow rate is not to exceed 78.4 dBA at 1 m (4'), and for interior spaces, sound emitted through supply and return air openings is not to exceed 82 dBA at 1.5 m (5').

.3 Housing

.1 Unit housing shall be constructed of 20 Gauge G-90 galvanized steel. The wall panels and roof panels shall be fabricated by forming double-standing, self-locking seams that require no additional support. The floor and wall panels shall be caulked air tight with a silicone caulk. All casing panels shall be attached with sheet-metal screws or rivets, which can be removed to field service large components. The unit base shall be suitable for curb or flat mount. The base shall be constructed of galvanized steel for improved rigidity. Base shall be structurally reinforced to accommodate the blower assembly and burner. Housing construction should be suitable for outdoor or indoor installation.

.2 All doors and at least one side of every sheet metal surface of the unit separating two air-masses of different air temperatures shall be faced with properly secured 1" aluminum-faced insulation for condensation prevention. The discharge of the unit (Down/Side/Up) shall be internal to the heating module containing the furnaces.

.3 All electrical controls on the control board shall be mounted in an isolated, fully enclosed and insulated vestibule, completely separated from any combustion air, but accessible for servicing needs.

.4 All furnace exhaust flues shall be of double-wall construction. All furnace exhaust flue connections and roof-penetration seams shall be sealed with High-Temp Fire-Barrier 2000+ type silicone caulking.

.5 All unit housings, sizes 1-3, shall be equipped with Internal Air Distribution Screens on the upstream side of each furnace heat-exchanger.

.6 All gas valves and electrical safety-limits shall be mounted within the burner vestibule; wiring to these components shall be properly secured and away from all high temperature metal surfaces. The burner vestibule shall be an integral part of the unit and not extend outside the exterior casing of the unit and not exposed to the main air stream.

.7 If an outdoor unit, high wind rain caps shall be installed at the termination of the furnace discharge flues.

.8 The vestibule full-size door shall provide easy access to controls and gas-train components. Blower door shall provide easy access to blower, motor and drives. Access doors shall be provided on both front and back side of unit providing full access to every part of the unit.

.9 The unit shall have double-wall construction consisting of at least two layers of 20 gauge G-90 galvanized steel.

.4 Blower

.1 Wheels shall be balanced in two planes and done in accordance with AMCA standard 204-96, Balance Quality and Vibration Levels for Fans. The wheel blades shall be aerodynamically designed to minimize turbulence, increase efficiency and reduce noise. The wheel blades shall be securely attached to the wheel inlet ring. The wheel shall be firmly attached to the fan shaft with set screws and keys. The blower assembly shall be isolated from the fan structure with vibration isolators.

.2 Blower capacity shall be per schedule.

.3 Blower(s) shall be forward-curved, centrifugal, Class I or II (depending on requirements of the application), double width, double inlet, constructed G-90 galvanized steel. Unit shall have a heavy-duty, solid-steel shaft.

.4 Direct drive blower assembly shall consist of a centrifugal backward inclined, non-overloading wheel secured directly to a heavy duty, ball bearing type motor via two set screws. The motor and wheel assembly shall be mounted to a heavy gauge galvanized steel frame. The motor shall be controlled by a variable frequency drive, allowing for variable airflow without the need of belts and pulleys.

.5 Motors shall be heavy duty ball bearing type and furnished at the specified voltage, phase and enclosure. Motor mounting plate shall be constructed of heavy gauge galvanized steel and shall be designed to provide easy adjustment of belt tension.

.6 Shafts shall be precision ground and polished. Heavy duty, pre-lubricated bearings shall be selected for a minimum (L50) life in excess of 200,000 hours of operation at maximum cataloged operating speed. They shall be designed for, and individually tested specifically for use in air handling applications.

.5 COOLING EQUIPMENT

.1 All cooling equipment should conform to local code requirements. All gas manifold components shall be piped and wired at the factory.

.2 Components Include:

.1 14 SEER minimum condenser

.2 Thermal Expansion Valve

.3 Filter/Dryer

.4 Hard Start Kit for Condenser

.5 Insulated Suction Lines

.6 Multiple Stages where required

.7 Pre Charged System

.8 R-410A Refrigerant

.6 GAS EQUIPMENT

.1 All gas equipment shall conform to local-Code requirements

.2 Components:

.1 modulating-gas valve

.2 on/off redundant gas valve

.3 burner

.4 main-gas shut-off valve

.5 main-gas regulator

.6 two solenoid valves

.3 All gas manifold components shall be piped and wired at the factory

.7 SAFETY CONTROLS

.1 motor starter with adjustable overloads

.2 main air-flow safety switch

.3 electronic flame-safety relay

.4 high-temperature limit switch

.5 non-fused disconnect

.6 flame roll-out switch

.7 main-gas regulator

.8 two solenoid valves

.9 modulating-gas valve

.10 burner

.11 combustion air-proving switch

.12 High gas-pressure switches to open circuit to electronic flame-safety relay, if gas pressure is too high.

.13 Low gas-pressure switch to open circuit to electronic flame safety relay, if gas pressure is too low.

.14 Adjustable low temperature blower-safety control with bypass timer to shut down unit, if discharge temperature drops below setting.

.8 ACCESSORIES

.1 Inlet Dampers: Manufacturer shall provide and install on unit, when possible, a two-position, motor-operated damper with internal end switch to energize the blower-starter circuit, when damper is 80% open. Blades shall be a maximum of 6" wide 16 Gauge G-90 galvanized steel shall be made to guarantee the absence of noticeable vibration at design air velocities. Damper blades to be mounted on friction-free synthetic bearings. Damper edges shall have PVC coated polyester fabric mechanically locked into blade edge. Jamb seals to be flexible metal, compression type.

.2 Filters: The filters shall be (2") thick, aluminum mesh, coated with super-filter adhesive. Aluminum-mesh filters shall have aluminum frames with media to be layers of slit and expanded aluminum, varying in pattern to obtain maximum depth loading. Washable 2" filters shall be enclosed in two-piece, die-cut frame with diagonal supports. Frame shall be constructed of heavy-duty beverage board. Filter media is supported on the air leaving side by a metal grid.

.3 Filter Section: shall be (insulated) constructed of G-90 galvanized steel with filters supported by internal slides and with removable access panels. Filters shall be provided in a v-bank arrangement.

.4 Fresh-Air Inlet Hood: Shall be constructed of G-90 galvanized steel with birdscreen.

.5 Fresh-Air Inlet Hood/Filter Combination: Shall be constructed of G-90 galvanized steel with birdscreen and (2") cleanable filters supported by internal slides mounted in the inlet face of the hood.

.6 Discharge Diffusers: Shall be constructed of G-90 galvanized steel with horizontal and vertical blades capable of four-way diffusion.

.7 Curb: 20" curb shall be constructed of 18 ga G-90 galvanized steel as a completed welded assembly.

.8 Cooling Coil Section: Cooling coil section shall be bolted directly to discharge of blower section. Coil section to be designed to fit onto common curb with main unit. Base of coil section to be constructed same as main unit with double pitch stainless steel drain pan for coil. Casing and roof to be 20 ga. G-90 galvanized construction. Inside of section to be fully insulated with foil back insulation. DX or chilled water coil to meet scheduled requirements.

.9 TEMPERATURE CONTROL SYSTEMS

.1 BAS (Building Automation System) Control: For building exhaust-air replacement with modulated temperature control based off of BAS supplied 0-10 Vdc or 4-20mA input signal. Auxiliary contacts and relays provided for contractor in the field.

.10 VAV

.1 VAV (Static Pressure Control): A factory-supplied field wired ECM is provided which varies the speed of the blower wheel. The WCM is controlled by a field wired Static Pressure Controller which measures building pressure and closes and opens contacts on the WCM to accelerate of decelerate the blower speed to maintain the building pressure set on the Static Pressure Controller. Factory supplied automatic dampers maintain the burner profile pressure drop as the blower speed is varied.

.2 Operating lights mounted in a remote-control panel to indicate: power, burner ON and blower ON.

.11 WIRING AND ELECTRICAL

.1 The control circuit voltage shall be 24 volts.

.2 A control transformer shall be provided.

.3 Unit shall have standing 120 Vac power.

.4 The control wiring shall be carried in wire channel or conduit.

.5 Wiring in control enclosures shall be in accordance with the National Electrical Code and the local code, as it may affect the installation.

.6 Motor starter shall be provided.

.7 Starter shall be line voltage, definite purpose type.

.8 Unit(s) shall be complete with all items such as relays, starters, switches, safety controls, conduit and wire as previously mentioned, and as required for proper operation.

.9 All factory-mounted controls shall be factory prewired to the unit control panel.

.10 Each condenser shall have a separate circuit enabling the supply fan motor to accept signals from a VFD without interfering with condenser operation.

.11 Single point electrical connection shall be supplied.

.12 Additional Components

.1 Blower-on delay timer to pre-heat the heat-exchanger prior to energizing the main blower.

.2 Convenience outlet shall be provided on the control board with 120 Vac service.

.3 Freeze-stat shall be provided with adjustable dials for time and temperature settings to shut down the main blower in case of burner failure.

.4 Fire stat with adjustable set-point temperature.

.5 Dirty filter airflow switch with LED indicator light on remote panel.

.6 Cabinet heater strip with thermostat.

.7 ECM Drive for main blower motor.

.8 Roof mounting curb factory supplied loose and ready for site assembly and insulation, 405 mm (16") high, complete with wood nailer and site assembly hardware.

.9 Factory secured seismic restraint connection hardware.

3 Execution

3.1 INSTALLATION OF MAKE-UP AIR UNIT

.1 Provide a gas fired make-up air unit on roof.

.2 Unless otherwise specified or required, provide required rigging and hoisting/moving equipment required to move units to required location. Perform rigging/hoisting/moving in accordance with unit manufacturer’s directions and details.

.3 Supply a curb for each unit, assemble curb, and hand curb to roofing trade on roof for installation and flashing into roof construction. Provide continuous gasketing around perimeter of curb between curb and unit mounting frame. Insulate curb with rigid weather-proof board type insulation in accordance with curb manufacturer's details.

.4 Install components shipped loose with units. Install a discharge air temperature sensor in supply ductwork approximately 2 m (6-½') downstream of unit and in accordance with manufacturer's recommendations.

.5 Brace and secure unit in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls for Mechanical Systems.

.6 For equipment/system manufacturer certification requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

.7 For equipment/system start-up requirements, refer to Section 20 05 00 – Common Work Results for Mechanical.

3.2 DEMONSTRATION AND TRAINING

.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 SUBMITTALS

.1 Submit shop drawings/product data sheets, complete with control components, and piping and wiring schematics.

.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 Consultant.

1.2 CLOSEOUT SUBMITTALS

.1 Submit a start-up and certification letter from equipment supplier as specified in Part 3 of this Section.

1.3 QUALITY ASSURANCE

.1 Split system air conditioning equipment and installation of equipment are to be in accordance with requirements of following:

- .1 All applicable provincial codes and standards;
- .2 ANSI/AHRI Standard 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

.2 Split system air conditioning system installation tradesmen are to be journeyman refrigeration mechanics.

.3 Acceptable manufacturers are:

- .1 Daikin Industries Ltd.;
- .2 Mitsubishi Electric Sales Canada Inc.;
- .3 Panasonic Canada Inc.
- .4 LG.

2 Products

2.1 GENERAL

.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 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 that may be required.

2.2 FAN COILS

.1 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 FXAQ – Wall Mounted Unit

- .1 Equal to Daikin indoor unit FXAQ, shall be a 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 The indoor unit's sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and 3.3 feet away from the unit.

.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.

.4 The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.

.5 The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

.6 The fan type shall be direct-drive cross-flow with statically and dynamically balanced impeller with high and low fan speeds available.

.7 Units shall be provided with a loose field installed condensate pump.

.3 FXSQ – 10" Concealed Ceiling Ducted Unit

.1 Equal to Daikin indoor unit FXSQ, shall be a built-in ceiling concealed 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 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.

.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.

.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).

.5 The unit shall ship from the factory in a rear return configuration and shall be field convertible to a bottom return configuration.

2.3 CONDENSING UNIT

.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 The system will automatically restart operation after a power failure and will not cause any settings to be lost.

.3 The unit shall incorporate an auto-charging feature to ensure proper refrigerant charge.

.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.

.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.

.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.

.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.

.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.

.9 The compressor shall be internally isolated to avoid the transmission of vibration.

.10 In the case of multiple condenser modules, operation hours of the compressors shall be balanced by means of the Duty Cycling Function

.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.

.12 Night setback control for low noise operation shall automatically limit the maximum speed of the fan motor.

.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.

.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 & Blister Rating:10).

.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.

.16 The outdoor unit shall be capable of cooling operation down to +23°F without any additional low ambient controls.

.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.

.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.

2.4 FLEX BRANCH SELECTOR BOX

.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 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.

.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).

.4 Manufacturers shall provide sound data for all branch selector boxes. If sound data is unavailable or exceeds the scheduled values, 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.

Model	Operating Sound dB(A)	Max Sound dB(A)
BSF4Q54TVJ	38	45
BSF8Q54TVJ	39	47

2.5 LOCAL CONTROLS

.1 Fan coil units shall be supplied with individual zone controllers, similar to Daikin model BRC1E73

.2 Zone controllers shall be hard wired by installing contractor.

.3 Controllers shall be able to function as follows:

.1 The controller shall have single and dual setpoints for occupied periods, and independent setback setpoints for unoccupied periods.

.2 The controller shall have the ability to digitally prohibit individual buttons and functions, including custom mode selection.

.3 The controller shall have a self diagnosis function that constantly monitors the system for malfunctions.

.4 The controller shall be equipped with a thermostat sensor.

.5 Controller shall have built-in 7-day, weekday plus Saturday Sunday (5+1+1), weekday plus weekend (5+2) and everyday (1) scheduler.

2.6 CENTRAL CONTROLS

.1 Provide an advanced multi-zone controller for installation in a common area as shown on the plans, equal to Daikin iTouch Manager. The controller shall have a 10” LCD touch screen display with the following screen views and functionalities:

.2 Central control of set points, schedules, fan speeds, heat/cool mode, and of setback (override) temperature settings during unoccupied periods.

.3 Adjustable temperature limits to restrict local wall mounted thermostat setpoint ranges.

.4 Visible and audible alarm indication of any system malfunctions with error code.

.5 Tiered hierarchy allowing for control of fan coil units independently or as a group.

.6 Remotely disable individual functions of the wall mounted zone controllers.

.7 Web enabled for remote access from PC, tablet or portable device and automatic alert and error emails.

.8 The following two automatic changeover methods shall be available. One shall be selected upon commissioning.

.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 ± 2°F (adjustable), the central controller shall change over the system automatically.

.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.

.9 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.

.10 Upon any changeover, a guard timer shall prevent another changeover for a period of 15, 30, or 60 (default) minutes.

.11 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) ± 1°F (adjustable)

.12 “3D” Floor plan graphic layout

.13 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”.

.14 Floor plan layout shall be displayed both on the local central controller, as well as accessible from the web.

.15 Floor plan will include capability to control indoor unit, and auxiliary inputs / outputs, such as designated lighting control, as follows:

.16 Up to 4 status points to be assigned to the control point icon (room name, room temperature, set point, and mode).

.17 Status and control points to display on corresponding location of zone served on floor plan.

.18 Digital input and output icons will display On/Off status.

.19 Analog input icons will display analog value.

.20 Up to 60 floor layout sections shall be possible depending on project scope.

.21 The iTM BACnet Server Gateway Option shall be capable of making the iTouch Manager work as a BACnet gateway using the BACnet/IP protocol. The iTM BACnet Server Gateway Option shall be capable of exposing indoor unit management points as BACnet objects to the BMS.

.22 The iTM BACnet Server Gateway Option shall allow the following functions:

- .1 Support Change of Value (COV) notifications.
- .2 Provide unique virtual BACnet device identification number (ID) for every indoor unit group address.
- .3 The iTM 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.

.23 In addition to the standard BACnet VRF points, the Building Management System shall monitor and/or control the following BACnet objects for indoor units:

- .1 Occupancy Mode: Unoccupied, Occupied, Standby
- .2 Cooling and heating setpoints during occupied and unoccupied modes.

.24 The Building Management System may choose to monitor and control the following BACnet objects linked to iTM control logic:

- .1 Enable/Disable iTM Schedule operation.
- .2 Enable/Disable iTM Auto Changeover Operation.
- .3 Set Timed Override Minutes - Monitor and configure timer extension for the indoor unit on iTM (30, 60, 90, 120, 150, 180 minutes)
- .4 System forced off - Enable/Disable all emergency stop programs that are registered on the iTM.

.25 The BMS shall have the ability to utilize scheduling functions on the iTouch Manager.

.26 The BMS shall have the ability to utilize automatic changeover function on the iTouch Manager, removing the need to program automatic changeover sequences on the BMS.

.27 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.

.28 All programming for monitoring and control of VRF system via the BACnet server shall be by BMS contractor, as per the Sequence of Operation.

2.7 ELECTRICAL

.1 Independent electrical power for fan coils and branch selector boxes shall be 208/230 volts, 1 phase, 60 hertz. The unit shall be capable of operating within the limits of 187 volts to 253 volts.

.2 Unless limited by local electrical codes and standards, multiple fan coils and branch selector boxes can be connected to the same breaker. Field provided individual disconnect switches for each fan coil are required.

.3 Electrical power for condensing units shall be 208/230 volts, 3 phase, 60 hertz. The unit shall be capable of operating within the limits of 187 volts to 253 volts.

.4 The control voltage between the indoor and outdoor unit shall be 16VDC. The control wiring shall be communication type stranded non-shielded 18-2 AWG.

.5 Control wiring shall be installed in a daisy chain configuration between all VRF components as per Manufacturer.

3 Execution

3.1 INSTALLATION

.1 Provide VRF equipment consisting of exterior condensing units and indoor evaporator units as scheduled and/or indicated on the drawings.

.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 Contractor shall inspect all equipment upon delivery and notify shipping company and manufacturer immediately of any damage.

.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.

.5 Indoor evaporator units to be installed as located on the drawings. Confirm exact location prior to roughing-in.

.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.

.7 Connect condensing unit and indoor evaporator units with refrigerant piping in accordance with piping shop drawing schematic. Refer to Section 23 23 00 – Refrigerant Piping. Provide any required additional refrigerant.

.8 High/low pressure gas line, liquid, and suction lines must be individually insulated between the outdoor and indoor units.

.9 Use refrigeration best practice to allow pipes to expand and contract freely. Review manufacturer installation instructions to ensure expansion joints are properly designed.

.10 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.

3.2 STARTUP AND ADJUSTING

.1 Pressure test all systems to 550 PSI after system was vacuumed and held to below 500 microns for at least one hour. Review manufacturer installation instructions for proper pressure test procedures.

.2 Design and install all piping as per TSSA and CSA B52 regulations and apply and obtain TSSA certification for all systems.

.3 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 Submit shop drawings/product data sheets for electric heaters, including accessories.

.2 Submit a site start-up report from manufacturer's representative as specified in Part 3 of this Section.

.3 Submit manufacturer's standard colour chart.

2 Products

2.1 GENERAL RE: ELECTRIC HEATERS

.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 Acceptable manufacturers are:

.1 Ouellet Canada Inc.;

.2 Chromalox Inc.;

.3 Stelpro Design Inc.

2.2 MOTORIZED CABINET HEATERS

.1 Surface mounted or recessed cabinet heaters as shown, each complete with:

.1 #18 gauge steel cabinet and removable front panel with integral louvers and grille with rounded corners;

.2 tubular steel heating element with aluminium fins;

.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;

.4 factory installed, tamperproof, adjustable thermostat;

.5 factory supplied enclosure accessories as indicated on drawings and/or heater schedule;

3 Execution

3.1 INSTALLATION OF ELECTRIC HEATERS

.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.

.2 Locate electric heaters for electrical trade so accurate electrical rough-in can be made. Confirm exact locations prior to electrical rough-in.

.3 Ensure heaters are properly installed.

.4 Where remote thermostats are indicated, provide thermostats and required control wiring and accessories. Unless otherwise indicated, locate thermostats 1.4 m (5') above floor, and confirm exact thermostat locations prior to roughing-in.

.5 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

3.2 DEMONSTRATION AND TRAINING

.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 SUBMITTALS

.1 Submit shop drawings/product data sheets for products specified in Part 2, including accessories.

.2 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.

.3 Submit a site inspection and start-up report from manufacturer’s representative as specified in Part 3 of this section.

.4 Submit 3 identified keys for cabinet doors for each humidifier prior to Substantial Performance of the Work.

2 Products

2.1 ELECTRIC/ELECTRONIC STEAM HUMIDIFIER

.1 Dristeem CSA certified, package type, 3-phase, 60 Hz, fully automatic electric/electronic steam humidifier in accordance with drawing schedule, capable of discharging pure steam with no mineral dust carryover, and complete with:

- .1 1.3 mm (0.05") thick enamelled steel barriered wall mounting cabinet with hinged and lockable door with interlock switch for the 3-phase power electrical section, an additional door to isolate line voltage components, and a separate plumbing compartment;
- .2 disposable plastic water/steam cylinders with mesh electrodes;
- .3 solenoid drain and fill valves;
- .4 control panel with self-diagnostic microprocessor-based control system with LCD display and keypad, steam capacity adjustment, manual drain activation pushbutton, rest pushbutton, digital operation and fault indication and display, and LED indication for current draw, humidistat demand, steam output, capacity adjustment, draining, normal operation and cylinder full, self-check on start-up, and automatic drain of cylinder at end of season;
- .5 duct or plenum mounting steam distributor assembly with a length to suit mounting location, complete with condensate separator and return leg;
- .6 required lengths of steam supply and condensate return hose;
- .7 wall mounting 24 volt adjustable tamper-proof humidistat with 10% to 90% RH range;
- .8 duct mounting differential pressure switch for air flow proving interlock;
- .9 condensate pump and condensate tempering assembly;
- .10 duct mounting adjustable high limit humidistat.

.2 Acceptable manufacturers are:

- .1 Dristeem;
- .2 Nortec Division (Climate Canada) Ltd.;
- .3 Aprilaire Inc.;
- .4 Vapac Humidification;
- .5 Armstrong International Ltd.;
- .6 Hygromatic (Spirax Sarco);
- .7 Carnes Co.;
- .8 Northern Industrial Humidifiers "Neptronic";

.9 Condair.

2.2 DEHUMIDIFIER

.1 Dehumidifier equal to Aprilaire Model 1850 ceiling hung, self-contained, dehumidifier, as follows:

.1 corrosion-resistant aluminum coils;

.2 removable duct connections;

.3 return air filter;

.4 11.9 gallons per day removal capacity;

.5 built-in digital control with top and front mounting options;

.6 remote control panel;

.7 smart control to automatically start dehumidification when humidity above target is sensed.

.2 Acceptable manufacturers are:

.1 Aprilaire Inc.;

.2 Honeywell;

.3 Anden.

3 Execution

3.1 INSTALLATION OF ELECTRIC/ELECTRONIC STEAM HUMIDIFIERS

.1 Provide electric/electronic steam humidifiers.

.2 Secure each steam generator assembly in place, level, and plumb, in accordance with manufacturer’s instructions.

.3 Install steam distributor manifold assemblies and secure in place. Coordinate installation with sheet metal trade.

.4 Connect steam generators and distribution manifolds with steam and condensate hose kits supplied with humidifiers. Install in accordance with manufacturer’s instructions.

.5 Install humidistats and pressure differential air flow proving switches and connect with 24 volt control wiring in conduit to steam generator control panel.

.6 Supply a spare water/steam cylinder for each unit and 3 identified keys for each steam generator cabinet and hand to Consultant at site prior to Substantial Performance of the Work.

.7 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.8 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.9 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.

.10 When installation is complete, arrange for the humidifier manufacturer to visit site to supervise start-up, testing and adjusting of each humidifier, including all controls and safeties, and when this work is complete, obtain from manufacturer and submit a letter stating humidifiers have been properly installed, started, adjusted, and are in proper operating condition.

3.2 INSTALLATION OF DEHUMIDIFIERS

.1 Provide dehumidifiers.

.2 Secure in place, level, and plumb, from structure by means of galvanized steel hanger rods with galvanized steel hardware, and vibration isolation spring hangers. Ensure unit drain pan is connected with properly sized, insulated condensate drainage piping terminated over a suitable drain point.

.3 Brace and secure equipment in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls for Mechanical Systems.

.4 Install humidistat. Confirm exact locations prior to roughing-in.

.5 Perform required control wiring (except building automation system connection) in conduit in accordance with manufacturer's control wiring schematics and wiring standards of the electrical work.

.6 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.7 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.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.

End of Section

1 General

1.1 SUBMITTALS

.1 Submit shop drawings/product data sheets for following:

.1 all control system components;

.2 identified schematic control diagrams with component identification, catalogue numbers, and sequence of operation for all systems;

.3 certified wiring diagrams for all systems.

.2 Submit following samples for review:

.1 control damper section with linkage, operator, and certified flow and leakage data;

.2 wall mounting control system flow diagram as specified in Part 2 of this Section;

.3 each type of thermostat to be used, each identified as to intended use.

.3 Submit a site inspection and start-up report from manufacturer’s representative as specified in Part 3 of this Section.

.4 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.

1.2 QUALITY ASSURANCE

.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.

.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

.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:

.1 extruded 6063T5 aluminum frame and airfoil blades, each with an integral slot to receive a gasket;

.2 extruded TPE frame gaskets and extruded EPDM blade gaskets;

.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 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.

.3 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.

.4 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.

2.2 LOCAL CONTROL PANELS

.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

2.3 CONTROL SYSTEM COMPONENTS

.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 Sensor/transmitter input devices must be suitable in all respects for the application and mounting location. Devices are as follows:

- .1 unless otherwise specified, temperature sensors are to be resistance type, either 2-wire 1000 ohm nickel RTD or 2-wire 1000 ohm 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, ±1°C (±0.5°F);
  - .2 all other points, ±0.75°C (±1.3°F).
- .2 room temperature sensors constructed for surface or recessed wall box mounting, complete with an adjustable set-point reset slide switch with a ± 1.66°C (±3°F) range, individual heating/cooling set-point slide switches as required, a momentary override request pushbutton for activation of after-hours operation, an analogue thermometer;
- .3 outside air sensors designed and constructed for ambient temperatures and to withstand environmental conditions to which they are exposed, complete with a NEMA 3R enclosure, solar shield, and a perforated plate surrounding sensor element where exposed to wind velocity pressure;
- .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;
- .5 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 20% to 80% RH at 25°C (77°F) and equipped with non-interactive span and zero adjustments, and a 2-wire isolated loop powered, 4-20 mA, 0 to 100% linear proportional output;
- .6 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:
  - .1 measurement range: 0 to 2000 ppm;
  - .2 accuracy: ±100 ppm;
  - .3 repeatability: ±20 ppm;
  - .4 drift: ±100 ppm per year;
  - .5 output signal: 0 to 10 VDC proportional over the 0 to 2000 ppm range.

.3 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 to 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:

.1 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.

.4 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:

.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 ±20° 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 places at equal distances along its length in accordance with ASHRAE Standards for duct traversing.

.2 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 (¾") 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;

.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.

.3 Static Pressure Traverse Probe: Duct mounting, complete with multiple static pressure sensors located along exterior surface of cylindrical probe.

.4 Shielded Static Air Probe: Indoor type or outdoor type as required, each with multiple sensing ports, an impulse suppression chamber, and air flow shielding.

.5 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 to 20 mA DDC compatible circuit for use by building automation system. Current transformer and current transducer are as follows:

.1 equal to Veris Industries split core current transformer with an operating frequency of from 50 to 400 Hz, 0.6 Kv class, 10 Kv BIL insulation, and 5 ampere secondary;

.2 equal to Veris Industries current to voltage or current to mA transducer with an accuracy of ±5%, a minimum load resistance of 30 kOhm, an input of 0 to 20 amperes and an output of 4 to 20 mA, and a 24 VDC regulated power supply.

.6 Honeywell Analytics microprocessor-based gas detection system, programmable monitoring and alarm equipment as indicated on drawings, CSA certified, in accordance with ANSI/UL 2017, General-Purpose Signaling Devices and Systems, ANSI/UL 2034, Single and Multiple Station Carbon Monoxide Alarms, and CAN/CSA C22.2 No. 61010, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use-Part 1: General Requirements, and as follows:

.1 Control Panel: Model 301C, 24 volt AC wall mounting NEMA 4 enclosure, capable of communicating with a building automation system to monitor exhaust fan status (primary or secondary), zone concentration and alarms through required protocol, and complete with:

.1 capability of communicating digitally with networked transmitters and relay modules through 3 RS-485 Modbus communication buses, each capable of accepting a combination of up to 32 addressable transmitters, relay modules, or annunciator panels at a maximum distance of 600 m (2000'), with power supply sufficient to power entire gas detection network;

.2 factory programmed software to enable required sequence of operation;

.3 3 internal DPDT relays rated at 5 amperes at 30 VDC, at fully programmable alarm levels and within programmable time delays, and capable of activating multiple relay modules of 8 external relays each at programmable alarm set-points and time delays;

.4 alphanumeric display indicating concentration and type of gas detected as well as location of sensor/transmitter, and 2 alarm levels for each sensing point;

.5 identified LED's to indicate Power, Alarm Levels A, B and C, and/or Fault;

.6 audible alarm rated at minimum 65 dBA at 1 m (3') that will fully activate at programmable levels;

.7 3 levels of continuous diagnostics to verify reading of each sensor/transmitter for abnormal sensing behaviour, loss of communication between control panel and sensor/transmitter, and program corruption analysis;

.8 capability of long term data logging to determine trends;

.9 capability of output communication through BACnet/IP to building automation system to monitor system status and to view logged historical data.

.2 CO and NO2 Sensors: Model E3SM-E3SCO with E3SRMNO2 remote sensor, 24 volt AC/DC wall mounting enclosure, capable of communicating with a building automation system to monitor exhaust fan status (primary or secondary), zone concentration and alarms through required protocol, and complete with:

.1 microprocessor-based, factory calibrated, ambient humidity and temperature compensated CO element capable of producing a RS-485 digital serial loop output signal to control panel;

.2 alphanumeric display indicating exact concentration and type of gas detected, and 2 alarm levels for each sensing point;

.3 identified LED's to indicate Power (green), and Alarm Levels A and B (amber);

.4 audible alarm rated at minimum 65 dBA at 1 m (3') that will fully activate at programmable levels;

.5 continuous monitoring electro-chemical sensors, one for carbon monoxide, one for nitrogen dioxide.

.3 SO2 Sensor: Sensepoint XCD RTD 3 wire, 4-20mA and RS485 MODBUS output fixed point detector with in-built alarm and fault relays for the protection of personnel and plant from toxic and oxygen hazards. Incorporating a transmitter with local display and optional remote mounted sensor, fully configurable via non-intrusive magnetic switch interface, and complete with:

.1 Sulphur Dioxide sensor.

.4 Acceptable manufacturers are:

.1 Honeywell Analytics/Vulcain Inc.;

.2 Mine Safety Appliance Co. (MSA);

.3 Armstrong Monitoring Co.;

.4 Quatrosense Environmental Ltd. (QEL).

.7 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:

.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 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 amperes 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;

.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;

.4 air pressure safety switches: equal to Johnson Controls Inc. or Cleveland Controls manual reset switches, each complete with SPDT contacts rated for 2 amperes at 120 VAC and an appropriate scale range and pressure adjustment;

.5 low temperature limit switches: manual reset type equal to Johnson Controls Inc. Model A70, each complete with DPST snap acting contacts rated for 16 amperes 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 element, and where sensing element does not provide full coverage of air stream, additional switches are to be supplied as required.

.8 Electronic signal isolation transducers equal to Advanced Control Technologies for installation whenever an anolog 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.

.9 Each manual override station is to be complete with contacts rated minimum 1 ampere at 24 VAC and is to provide following:

.1 integral H-O-A switch to override controlled device pilot relay;

.2 status input to building automation system to indicate whenever switch is not in the Auto position;

.3 status LED to illuminate whenever output is On;

.4 override LED to illuminate whenever H-O-A switch is in either the Hand or Off position.

.10 Electronic/pneumatic transducers equal to Johnson Controls Inc. transducers with an output of from 3 to 15 psig, an input of from 4 to 20 mA or 10 VDC, manual output adjustment, a pressure gauge, and an external replaceable supply air filter.

2.4 SYSTEM WIRING MATERIALS

.1 System wiring, conduit, boxes, and similar materials are to be in accordance with requirements specified in appropriate Section(s) of Electrical Work specification.

3 Execution

3.1 DEMOLITION

.1 Perform required control system demolition work.

.2 Refer to demolition requirements specified in Section 20 05 05 – Selective Demolition for Mechanical.

3.2 GENERAL RE: INSTALLATION OF CONTROLS

.1 Provide complete systems of control and instrumentation to control and supervise building equipment and systems in accordance with this Section and drawings.

.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 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.

.4 Brace and secure control system equipment in accordance with requirements specified in Section 20 05 48.16 - Seismic Controls for Mechanical.

3.3 SUPPLY OF CONTROL AIR DAMPERS AND OPERATORS

.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.

.2 Unless otherwise specified or scheduled, insulated dampers to be provided for all outdoor air intake and exhaust air applications.

.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.

.4 Where sequence operation is indicated, or where multiple operators drive a series of dampers, provide pilot positioners to couple their action.

.5 Ensure dampers located in ductwork other than galvanized steel are constructed of type 316 stainless steel.

3.4 INSTALLATION OF THERMOSTATS

.1 Unless otherwise noted, provide required thermostats.

.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 Unless otherwise indicated, mount room thermostats 1.5 m (5 ft.) above finished floor level. Confirm exact location of thermostats prior to roughing-in.

.4 Provide stand-off mounting and an insulated sub-base for thermostats on outside walls.

.5 Perform control wiring associated with installation of electric or electric-electronic thermostats.

3.5 INSTALLATION OF CONTROL SYSTEM COMPONENTS

.1 Provide required control system components and related hardware. Refer to drawing control diagrams and sequences.

.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.

3.6 INSTALLATION OF GAS DETECTION SYSTEM

.1 Provide gas detection system sensor/transmitter and control panel equipment for areas where indicated and/or specified on drawings.

.2 Confirm exact locations of equipment prior to installation.

.3 Perform required 24 volt wiring in conduit to control panel(s) and from each panel to associated sensor/transmitter units as required and in accordance with wiring requirement specified in the electrical work specification and system manufacturer's certified wiring schematics. Provide 24 volt interlock wiring to exhaust fan starters in accordance with drawing control requirements.

3.7 CONTROL WIRING

.1 Perform required control wiring work for control systems except:

  .1 power wiring connections to equipment and panels, except as noted below;

  .2 control wiring associated with mechanical plant equipment and systems whose control is not part of work specified in this Section;

  .3 starter interlock wiring.

.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 Control wiring in ceiling spaces and wall cavities may be plenum rated cable installed without conduit but neatly harnessed, secured, and identified.

.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 IDENTIFICATION AND LABELLING OF EQUIPMENT AND CIRCUITS

.1 Refer to identification requirements specified in Section 20 05 00 – Common Work Results for Mechanical.

.2 Identify equipment as follows:

  .1 enclosures and components: engraved laminated nameplates with wording listed and approved prior to manufacture of nameplates;

  .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.

3.9 TESTING, ADJUSTING, CERTIFICATION, START-UP, AND TRAINING

.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.

.2 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.3 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.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.

.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 Abbreviations used in this Specification are as follows:

.1 BAS building automation system;

.2 DDC direct digital controls;

.3 LAN local area network;

.4 PC personal computer.

1.2 SUBMITTALS

.1 Submit shop drawings/product data sheets for BAS components. As a minimum, submit the following:

.1 BAS network architecture, including modes and interconnections;

.2 systems schematics, sequences, and flow diagrams;

.3 points schedule for each point in BAS, including point type, object name, expanded ID, display units, controller type, and address;

.4 samples of graphic display screen types and associated menus;

.5 detailed Bill of Materials for each system or application, identifying quantities, part numbers, descriptions, and optional features;

.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;

.7 control valve schedules including a separate line for each valve and a column for valves as for control dampers;

.8 room schedule including a separate line for each HVAC terminal unit indicating type, location and address;

.9 details of BAS interfaces and connections to other systems;

.10 product data sheets or marked catalogue pages including part number, photograph and description for BAS hardware and software.

.2 Submit a site inspection and start-up report from manufacturer's representative as specified in Part 3 of this Section.

1.3 DESCRIPTION OF THE BUILDING AUTOMATION SYSTEM

.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.

.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 graphic user interface for accessing and viewing BAS information, commanding points, changing setpoints, responding to alarms, programming time-of-day schedules;

.2 operator information, alarm management, and control features;

.3 enterprise-level information and control access;

.4 information management including monitoring, transmission, archiving, retrieval, and reporting functions;

.5 diagnostic monitoring and reporting of BAS functions;

.6 off-site monitoring and management access;

.7 energy management;

.8 standard applications for terminal HVAC systems.

.3 BAS to be installed/hosted on City of Brampton virtual server to be allocated to the vendor.

.1 Virtual Server is owned by the City of Brampton and will house all software pertaining to the BAS.

.2 City of Brampton's Digital Innovation Team will provide access to the BAS vendor to the server to install, interface and configure the new BAS.

.3 Server supplied by vendor for BAS operations is not acceptable. BAS Vendor is responsible to interface the new BAS to the available server.

.4 All trends, graphs and database to reside on the Virtual Server.

.4 BAS is to include, but not be limited to, following:

.1 remote network access to the BAS installed in the City of Brampton virtual server;

.2 portable operator's terminal;

.3 network of standalone network automation engine(s);

.4 network of field equipment controllers;

.5 input/output modules;

.6 local display devices;

.7 distributed user interfaces;

.8 network processing, data storage and communication equipment;

.9 all other components required for a complete and operating BAS.

1.4 QUALITY ASSURANCE

.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

.1 Control systems are to follow the City of Brampton BAS Guidelines as specified in Section 25 05 02.01 CoB Energy Management Guide & Compendium Article 2.4 Building Automation Systems and Appendix – BAS Design and Implementation Principles. Where conflicts arise between this specification section and the City of Brampton BAS Guidelines, the City of Brampton BAS Guidelines shall govern.

.2 Control system components (field devices) other than those specified in this Section are generally specified in Section 25 05 01 - Automatic Control Systems. Component's factory installed with equipment or supplied with equipment are specified in mechanical work Sections with equipment.

.3 BAS specified in this Section is an expandable DDC building automation system in accordance with drawing control diagrams and sequences, and points lists. Acceptable manufacturers are:

.1 Johnson Controls Canada LP;

.2 ESC Automation Inc.;

.3 Siemens Canada.

2.2 BAS ARCHITECTURE

.1 The network is to follow a 2-tier structure

.1 BCs and AWS to be on Tier1. These are to be IP-Based controllers and connected directly to CoB's base network infrastructure.

.2 AACs, ASCs, and other field controllers to be on Tier 2. These are non-IP controllers and to be connected through MS/TP infrastructure originating from the BCs

.2 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.

.3 Network automation engines are to provide supervisory control over control network and are to support BACnet/IP and BACnet Standard MS/TP bus communication protocol (ASHRAE SSPC-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.

.4 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 DISTRIBUTED WEB BASED USER INTERFACE

.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:

.1 software is to run on Microsoft Internet Explorer (8.0 or higher) browser;

.2 minimum hardware requirements are:

.1 2 GB RAM;

.2 2.0 GHz clock speed Pentium 4 microprocessor;

.3 120.0 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.

2.4 REMOTE ACCESS VIA SMART PHONE AND/OR TABLET DEVICES

.1 Available with an operator interface designed for use on various modern smart phone devices with network connectivity with the follow features:

.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 Solution written with HTML5 web standards and browser agnostic, not deploying or using ActiveX controls, nor requiring installation of Java Runtime engine.

.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.

.4 Without alternation, mobile user interface operable within any standard internet browser from a normal personal computer.

.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.

2.5 USER INTERFACE APPLICATION COMPONENTS

.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:

.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 user interface software is to provide help menus and instructions for each operation and/or application;

.3 system is to support customization of user interface configuration and a home page for each operator;

.4 system is to support user preferences in alarm, trend, display, and applications screen presentations;

.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.;

.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.

.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;

.8 operation of control system is to be independent of user interface, which is to be used for operator communication only.

.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.

.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:

- .1 log, date, and time of alarm occurrence;
- .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;
- .3 permit a user with the appropriate security level to acknowledge, temporarily silence, or discard an alarm;
- .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;
- .5 facilitate ability to direct alarms to an email address or alphanumeric pager, in addition to pop-up window described above;
- .6 any attribute of any object in system may be designated to report an alarm.

.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:

- .1 all points in BAS;
- .2 all points in each BAS application;
- .3 all points in a specific controller;
- .4 all points in a user-defined group of points;
- .5 all points currently in alarm;
- .6 all points locked out;
- .7 all BAS schedules;
- .8 all user defined and adjustable variables, schedules, interlocks, etc.

.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:

- .1 weekly schedules;
- .2 exception schedules;
- .3 monthly calendars;

.4 global schedules.

.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:

.1 each user is to have a user name (24 characters minimum), a password (12 characters minimum), and access levels;

.2 each user may change his or her password at any time;

.3 when editing or entering passwords, system is not to echo actual characters for display on monitor;

.4 minimum of 500 unique password is to be supported;

.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;

.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;

.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.

.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.

.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:

.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 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 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;

.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.

.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.

.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 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:

.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 each automation engine or server is to 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.

.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:

.1 capability of retrieving any historical database point for use in displays and reports by specifying point name and associated trend name;

.2 displays which are able to be single or stacked graphs with on-line selectable display characteristics such as ranging, colour, and plot style;

.3 display magnitude (zoom capability) and units selectable by operator at any time without reconfiguration of processing or collection of data;

.4 display magnitude is to be automatically scaled to show full graphic resolution of data being displayed;

.5 trend studies are to be capable of calculating and displaying calculated variables including highest value, lowest value, and time based;

.6 display is to support user’s ability to change colours, sample sizes, and types of markers.

.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:

.1 database management function is to include summarized information on trend, alarm, event, and audit for backup, purge, and restore database management functions;

.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.

.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;
.6 Shrinking A Database;
.7 Backing-Up A Database;
.8 Resetting Internet Information Services;
.9 Shutting Down BAS Deice Manager;
.10 Action Successful.

.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;

.5 system is to advise user via task bar icons and email messages when a database value has exceeded a warning or alarm limit;

.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.

.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.

.8 BAS is to indicate via taskbar icons and email messages when a database value has exceeded a warning or alarm limit;

.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:

.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 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;

.2 when Monitor Mode is engaged, system is to simulate shedding action but will not take any action.

.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;

.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;

.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;

.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;

.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;

.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.

.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;

.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;

.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;

.12 system is to equip user with a Load Tab that displays all demand limiting and load rolling parameters for any selected load;

.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.

.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;

.5 Ineligible Status;

.6 Active Timer;

.7 Time Remaining;

.8 Last Shed time.

2.6 NETWORK AUTOMATION ENGINES

.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 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:

.1 web-based user interface software is to be imbedded in each network automation engine;

.2 each network automation engine is to support a minimum of 4 concurrent users;

.3 user is to be capable of accessing all system data through one network automation engine;

.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;

.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;

.6 user interface is to support following functions using a standard version of Microsoft Internet Explorer:

.1 configuration;

.2 commissioning;

.3 data archiving;

.4 monitoring;

.5 commanding;

.6 system diagnostics.

.7 each network automation engine is to permit temporary use of portable devices without interrupting normal operation of permanently connected modems.

.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.

.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.

.5 Each network automation engine is to include an integrated, hardware based real time clock.

.6 Each network automation engine is to be equipped with LED indicators to identify following conditions:

.1 Power, On/Off;

.2 Ethernet Traffic, Ethernet Traffic/No Ethernet Traffic;

.3 Ethernet Connection Speed, 10 Mbps/100 Mbps;

.4 FC Bus A, Normal Communications/No Field Communications;

.5 FC Bus B, Normal Communications/No Field Communications;

.6 Peer Communication, Data Traffic Between Network Automation Engines;

.7 Run, NAE Running/NAE in Start-up/NAE Shutting Down/Software Not Running;

.8 Battery Fault, Battery Defective/Data Protection Battery Not Installed;

.9 24 VAC, 24 VAC Present/Loss of 24 VAC;

.10 Fault, General Fault;

.11 Modem RX, NAE Modem Receiving Data;

.12 Modem TX, NAE Modem Transmitting Data.

.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:

.1 2 USB ports;

.2 2 URS-232 serial data communication ports;

.3 2 RS-485 ports;

.4 one Ethernet port.

.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.

.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:

.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 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.

2.7 FIELD EQUIPMENT CONTROLLERS

.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 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.

.3 Each field equipment controller is to:

.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 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.

.3 support binary inputs configured to monitor either of following:

.1 dry contact maintained mode;

.2 pulse counter mode.

.4 support analog outputs configured to output either of following:

.1 analog output, voltage mode;

.2 analog output, current mode.

.5 support binary outputs, 24 VAC Triac;

.6 support configurable outputs capable of following:

.1 analog output, voltage mode;

.2 binary output mode.

.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') between field controller and furthest connected device.

.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') between field controller and furthest connected device.

.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;

.10 support, but not limited to, following:

.1 hot water, chilled water/central plant applications;

.2 custom air handling units for special applications;

.3 terminal units;

.4 special programs as required for systems control.

.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.

2.8 INPUT/OUTPUT MODULES

.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.

2.9 SYSTEM CONFIGURATION TOOLS

.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:

.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 tool is to have capability to automatically discover field devices on connected buses and networks;

.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;

.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 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:

.1 Power: On/Off;

.2 Fault: Fault/No Fault;

.3 SA/FC Bus: Bus Activity/No Bus Activity;

.4 Bluetooth: Bluetooth Communication Established/Bluetooth Communication Not Established.

2.10 WIRING MATERIALS

.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

.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).

.2 Unless otherwise specified, perform BAS work in accordance with system manufacturer’s instructions.

3.2 INSTALLATION OF DIRECT DIGITAL CONTROL SYSTEM COMPONENTS

.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.

.2 Provide operator workstation in a location as directed by the Owner.

.3 DDC work is to be performed by skilled technicians, properly trained and are qualified for this work.

.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.

.5 System is to be modular, permitting expansion by adding hardware and software without changes in communication or processing equipment.

.6 Provide new communications bus as required complete with required ancillaries. Connect and extend existing communications bus.

.7 Provide 1 supervisory controller (SC) per cabinet fan (air handler). Provide necessary field equipment controllers (FEC).

.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.

.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.

.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.

.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 No. 18 AWG twisted-shielded cable. Other types of wire required are to be as recommended by system supplier.

.12 Provide required sensors, remote devices, etc., and required interface accessories. Mount duct and/or plenum sensors half-way across duct or plenum.

.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.

.14 Supply and turn over to 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:

- .1 process control language (PCL) logs;
- .2 control loop logs;
- .3 PCL master point.

.15 Submit Point Data Input forms to Consultant that Owner will fill out with DDC system supplier's assistance. Input this point data into the system.

.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

.1 Implement energy management programs indicated for building equipment and systems.

.2 Ensure energy management program adjustable parameters are accessible to and adjustable by building operations personnel at operator’s workstation.

.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

.1 Perform required control wiring work for control systems except:

  .1 power wiring connections to equipment and panels, except as noted below;

  .2 control wiring associated with mechanical plant equipment and systems whose control is not part of work specified in this Section;

  .3 starter interlock wiring.

.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 Control wiring in ceiling spaces and wall cavities may be plenum rated cable installed without conduit but neatly harnessed, secured, and identified.

.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

.1 Refer to Section 20 05 00 – Common Work Results for Mechanical.

.2 Identify BAS equipment as follows:

  .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;

  .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;

  .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;

  .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 TESTING, ADJUSTING, CERTIFICATION, START-UP, AND TRAINING

.1 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system manufacturer certification requirements.

.2 Refer to Section 20 05 00 – Common Work Results for Mechanical for equipment/system start-up requirements.

.3 Include for demonstration and training sessions for each of 2 groups of Owner’s operating and maintenance personnel as follows:

.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;

.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 2 full, 8 hour day seasonal (summer-winter) site sessions to perform additional instruction regarding seasonal changes and how they affect BAS.

.4 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.

3.7 PROJECT CLOSEOUT WORK

.1 Record "as-built" drawings are to include:

.1 schematic outline of BAS for quick reference of overall system scope;

.2 adequate record of work as installed, including locations and routing of system wiring.

.2 O&M Manual is to include:

.1 hardware specification manual which gives a functional description of hardware components;

.2 operator's manual which outlines concise instructions for operation of system and an explanation and recovery route for system alarms;

.3 engineering manual which outlines and defines system set-up, definition and application;

.4 data manual which indicates applications data programmed into system;

.5 system software documentation.

End of Section

Energy Management Guide and Compendium

Version 2.1

April 2021

This document was created in support of the City of Brampton's 2019-2024 Energy & Emissions Reduction Plan:

Prepared by:

Energy Management
Facilities, Services and Operations,
Community Services Department

TABLE OF CONTENTS

DOCUMENT HISTORY

Version	Date	Revisions
1.0	September 6, 2019	Indoor Pool, Gymnasium and Administration Spaces
1.1	October 29, 2019	Transit Facilities
1.2	January 21, 2020	Building Control and Automation
1.3	April 1, 2020	Building Control and Automation Appendices Revised TOC Layout for Design, Implementation & Operations
2.0	April 22, 2020	Operations Section
2.1	April 21, 2021	Update to BAS Vendors list

Section I. Introduction

Chapter 1. Energy Management Mandate

The Energy Management Team's mandate is to minimize energy and emissions and maximize cost recovery for the City's portfolio of owned and managed facilities.

Chapter 2. Purpose of A Zero Carbon Transition

As a Green City, Brampton has committed to zero carbon and high performance facilities. This commitment for *A Zero Carbon Transition* has been formalized through the City of Brampton's latest 5-year Energy and Emissions Management Plan for 2019-2024. The plan outlines the action plan to achieve a zero carbon transition for the City's new and existing corporate facilities. In accordance with the Paris Agreement, Brampton has adopted the provincial and federal greenhouse gas (GHG) emission reduction targets of 30% and 80% for 2030 and 2050, respectively, using a 2010 baseline. The City has set an interim target of 20% GHG emissions reduction by 2024. The Energy Management (EM) Team at the City is committed to the following three key objectives under this plan: to minimize emissions intensity, to minimize energy intensity, and to maximize cost recovery.

The standard approach for decreasing facility GHG emissions is the reduction of fossil fuel use required to heat, cool and power buildings through energy efficiency. As a result of energy conservation measures implemented in City owned facilities and decreasing emission factors due to the elimination of Ontario's coal plants for the production of electricity, GHG emissions for City facilities have decreased over time. However, in order to meet the aggressive targets of the City's 2019-2024 Energy and Emissions Management Plan, and federal and provincial GHG reduction commitments, there is a need to drive GHG reductions at a much faster rate. To do this, both energy use and carbon emissions need to be reduced simultaneously by transitioning to zero carbon. The transition includes design, construction and operating practices, which are all covered within this guide.

Chapter 3. About this Guide and Compendium

3.1 Intended Audience and User Groups

This guide is intended to provide guidance to the following identified user groups:

Internal to the City of Brampton:

- Community Services
    - Recreation
    - Building Design & Construction (BDC)
    - Facilities Operations and Maintenance (FOM)
    - Facilities Maintenance (FM)
        - Outside Service Contracts
    - Facilities Services and Operations (FSO)
        - Energy Management Team
    - Capital Planning and Asset Management
- Public Works and Engineering
- Transit
- Fire and Emergency Services

External to the City of Brampton:

- Consultants
- Architects
- Engineers
- Contractors

Why have these groups been identified?

- To ensure that energy performance is more than just an afterthought, it needs to be raised to the same level as corporate financial targets and operating objectives. This will facilitate commitment and buy-in from all stakeholders involved.
- To facilitate an integrated design process[1]
- A project's failure to reach a zero energy goal can be the result of roadblocks that occur at any stage. At each stage, roadblocks can clog the path to zero energy and prevent the project from achieving its potential. A successful team navigates each of these roadblocks and has strategies and lessons learned to overcome each challenge. They carry ownership of the zero energy goal from stage to stage and elevate the priority of building energy performance. [2]
    - Including zero energy in the City's preferences during the request for proposals (RFP) stage greatly increases the likelihood that teams with zero energy expertise will be selected.
    - Proper oversight of the estimating team during the project can eliminate errors due to unfamiliarity with energy efficiency and renewable systems and keep the project on path.
    - Maintaining and communicating the priority of the zero energy goal throughout the process
    - Through the final bid and value-engineering stages ensures that the systems and components necessary for achieving that goal will not be eliminated from the project.
    - Through the operation of the facility, the operational staff and end-users play a crucial role in running the facility with a conservation and zero carbon mindset
- Architects as designers are to adopt the features of energy conservation in designing new buildings and renovating existing buildings. designing and detailing effective building envelope systems, knowledge of the increased importance of embodied carbon in building materials when targeting a net-zero carbon design[3]

While engineers play a crucial role in the design of more sustainable buildings, they often get involved too late in the design process. Many of the key decisions are taken in the earliest design stages, when building orientation, glazing ratio (ratio of area of glass to area of opaque wall), and the overall form of the building are decided. Once these critical decisions have been made, engineers can attempt to optimize a poor design, but it is difficult to arrive at low-carbon design without having engineers involved in the initial design. The challenge is to integrate engineering analysis in a manner that provides rapid feedback to architects and the rest of the design team early in the process.[4]

3.2 How to Use this Guide

This guide document aims to give various user groups guidance and recommendations to influence the City' portfolio of existing and new construction projects on the transition to zero carbon. The guide is presented in the following four sections:

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[1] This is further discussed in Section II of this guide

[2] Chapter 2, Maintaining Zero Energy Goals Throughout a Project. Advanced Energy Design Guide for Small to Medium Office Buildings – Achieving Zero Energy. ASHRAE 2019.

[3] Häkkinen, Tarja & Kuittinen, Matti & Ruuska, Antti & Jung, Nusrat. (2015). Reducing embodied carbon during the design process of buildings. Journal of Building Engineering. 4. 1-13.

[4] Ochsendorf, J. Challenges and Opportunities for Low-Carbon Buildings (2012), Massachusetts Institute of Technology.

1. Section I: Introduction

The Introduction provides the audience of this guide with background information on the City's Energy & Emissions Management Plan 2019-2014: A Zero Carbon Transition. In addition to providing background on the City's commitments and targets, this section also provides a high level overview of the purpose of a zero carbon transition, principles of success through energy management, and approaches to zero carbon.

2. Section II: Design

This section provides recommendations to encourage zero carbon or high performance energy design when compared with minimum building code requirements. This section applies to new construction and major renovation projects for City owned facilities. Recommendations in this section are presented with a considerations for an integrated design process (IDP) and energy modelling. Customized design considerations are presented by facility archetype.

3. Section III: Implementation

The implementation section is intended to provide recommendations to implement the design of zero carbon or high performance energy facilities. This section applies to new construction and major renovation projects that are City owned or managed.

This section is a WIP.

4. Section IV: Operations

The Operations section provides recommendations for the operation of zero carbon or high performance facilities. This section applies to all existing and new construction facilities that are City owned or managed.

This section provides an overview of operation processes, followed by customized facility operation strategies for various facility archetypes with a focus upon best operational practices and setpoints/schedules.

Chapter 4. Principles of Success

4.1 An Energy Management Pathway for Design, Implementation & Operations

For the pathway to be successful, the first step is creating a plan for new and existing facilities which was referenced in the Introduction. Energy targets for these individual facilities are created from the overall emissions target referenced in the City's Energy and Emissions Management plan. These targets need to be met at design, construction and most critically at the operational stages so that they persist throughout the life cycle of the building.

The World Building Design Guide recommends an integrated approach:

- "Reduce heating, cooling, and lighting demand through passive strategies such as climate-responsive design, daylighting, and conservation practices;
- Specify efficient HVAC and lighting systems that consider part-load conditions and utility interface requirements;
- Employ renewable energy sources such as solar heating for hot water, photovoltaics, geothermal space heating, and groundwater cooling, sized for the reduced building loads.
- Optimize building performance by employing energy modeling programs during design;
- Optimize system control strategies by using occupancy sensors, CO2 sensors, and other air quality alarms during operation;

- Monitor project performance through a policy of commissioning, metering, annual reporting, and periodic re-commissioning;
- Consider Retro-commissioning of buildings which were never originally commissioned; and
- Integrate water saving technologies to reduce the energy burden of providing potable water."

The first three bullets of this approach can also be used in a stepwise fashion so to maximize cost effectiveness. The capital cost of renewable energy sources or systems is significant and thus reducing the demand (bullet one) will reduce the capacity and cost of the system required to meet this demand.

Figure 1 illustrates this four step approach:

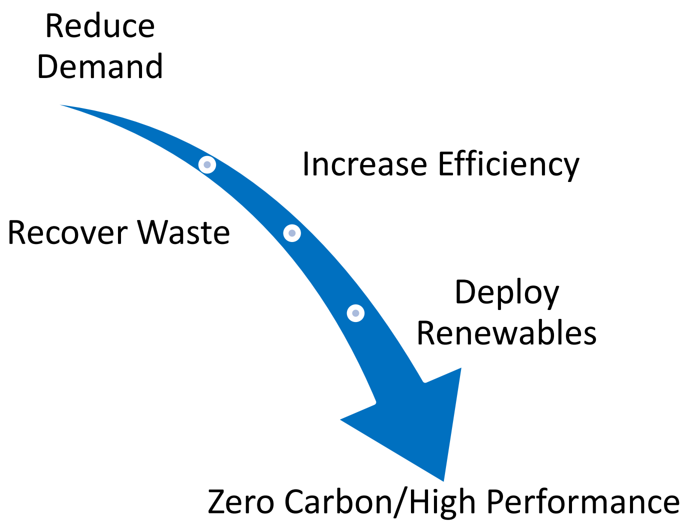

Figure 1 Four-Step Approach to an Energy Management Pathway

Chapter 5. Zero Carbon Approach

5.1 Purpose

This guide provides pathways to achieve zero carbon or high efficiency buildings, however it is acknowledged that with technology innovations there will continue to be developments for additional pathways to zero carbon that may not be covered within this guide and thus, it is a living document and will evolve over time. The recommendations in this guide are not designed to be code-enforceable. As a result, they are not intended to replace, supersede, or circumvent any applicable building codes and standards. This guide assumes that all minimum regulatory and energy code requirements are met by the project.

This guide focuses on reducing energy consumption in a building. There are also overlaps with other important aspects of sustainability. Acoustics, indoor air quality (IAQ), water efficiency and quality, landscaping, access to views, and effective space planning are just some of the other benefits of an effective design.

5.2 What is a Zero Carbon Facility?

A zero carbon facility has life-cycle GHG emissions which sum up to zero, or less. This includes the life-cycle impacts of the facility's design, construction, and operation practices.

Design & Implementation:

- Design prioritizes reducing energy demand and meeting energy needs efficiently.
- The embodied carbon of the building's structural and envelope materials is evaluated as part of the design. This includes carbon from the materials extraction, manufacturing, transportation to site, installation, disposal and end of life processing.[5]
- Install onsite renewable energy

Operations:

- The building demonstrates a zero-carbon balance in its operations. Over the course of a year, its operations contribute zero carbon emissions.
- Onsite renewable energy is used, either produced onsite or procured from offsite
- Tracking and reporting of the facility's energy consumption and associated GHG emissions

5.3 Zero-Over-Time (ZOT) Approach

A zero-over-time (ZOT) approach focuses on cost-effective energy efficiency and renewable energy by prioritizing projects that pay back quickly in the short term, while aligning larger energy efficiency projects with major building life-cycle events, like equipment upgrades. The ZOT approach sets commercial building portfolios on a financially viable path to achieve net zero energy.[6]

WIP

[5] Not the current focus of this guide

[6] Guide: Best Practices for Achieving Zero Over Time for Building Portfolios. Rocky Mountain Institute (2018) https://rmi.org/insight/zero-over-time-for-building-portfolios/

Section II. Design

Chapter 1. Purpose

According to the CaGBC, the cost of not adopting a zero carbon transition increases with each day[7]. Every building built today that is not designed to achieve near-zero carbon emissions is only contributing to a continued increase in carbon emissions. Facilities not built to zero carbon will require major investments in deep energy retrofits by 2050 to meet Canada's and the City of Brampton's GHG reduction targets. These retrofits will be costly and disruptive to building owner operators and tenants, and will need to occur before the normal 25 to 40-year cycle of significant re-investment in a building's infrastructure and major equipment[8].

1.1 Purpose

This design section is intended to provide recommendations to encourage zero carbon or high performance energy design when compared with the minimum building code requirements. This section applies to new construction and major renovation projects for City owned facilities.

This section will provide customized strategies as applicable for the following classifications with example archetypes shown in brackets.

- Recreation (e.g. community centres, including multi-purpose facilities with pools, ice rinks, gymnasiums, dance studios etc.)
- Transit & Works Operation (e.g. Transit Facilities, Public Works Yard)
- Corporate (e.g. Administrative Facility)
- Library
- Fire & Emergency Services (e.g. Fire Station Facility)

1.1.1. Benefits of Zero Carbon & High Performance Design

Zero carbon and high performance design will reduce corporate facility energy usage, minimize emissions and promote a culture of sustainability. This guide is also meant to provide the following additional benefits: improve life cycle costs and efficiency promote innovation, increase occupant comfort and satisfaction, and drive energy awareness amongst the audience and user groups mentioned previously.

Improve Life Cycle Costs and Efficiency

- Zero carbon design helps to provide long-term lower maintenance and operational costs for facilities as a direct result of energy efficient design and optimized building control and operation
- Commissioning of new facilities ensures facilities are constructed and will perform as designed.
- Buildings not built to zero carbon can undergo very costly future retrofits whereas zero carbon buildings have lower life-cycle costs and continue to conserve resources throughout the lifetime of the building
- Zero carbon provides resilience to owner-operators from future energy and carbon cost risks as there is a potential for the rise in cost of carbon emissions and the cost of traditional fuel sources

[7] The CaGBC found that zero carbon buildings on average can provide a positive financial return of 1% with an 8% capital cost premium. Over 25 years, the averaged cost of carbon pollution used for the CaGBC's study was $150/tonne. The starting cost was $50/tonne and an annual increase of $8/year was applied over 25 years. Reference: Making the Case for Building to Zero Carbon (2019), CaGBC. Accessed at: https://www.cagbc.org/cagbcdocs/advocacy/Making_the_Case_for_Building_to_Zero_Carbon_2019_EN.pdf

[8] Making the Case for Building to Zero Carbon (2019), CaGBC. Accessed at: https://www.cagbc.org/cagbcdocs/advocacy/Making_the_Case_for_Building_to_Zero_Carbon_2019_EN.pdf

Increasing Occupant Comfort, Satisfaction & Health[9]

- Properly designed and constructed, better insulated and tighter envelopes mean a quieter, more thermally comfortable workspace and a more durable building
- Some aspects of occupant satisfaction, such as physical and visual comfort, access to daylighted spaces, views to the outdoors, and natural ventilation, are achieved through effective building design and operation
- Productivity of occupants can be improved with a healthy, comfortable, energy-efficient environment
- Better building envelopes eliminate cold surfaces and drafts, reduce discomfort from higher heating and cooling demands, and provide views and daylighting while reducing glare and hot spots caused by thermal gain. They also ensure there are no health issues associated with moisture intrusion
- Better distribution of heating and cooling reduces temperature differences from one area to another. Air is provided at a lower velocity and at a temperature closer to that of the ambient air.
- Ventilation systems provide adequate fresh air to all spaces, and enhanced controls adjust to fluctuating occupancy rates to maintain temperature and air quality.

Drive Energy Awareness

- The development of a culture and mindset that moving towards higher performance and zero carbon building design is a good financial investment
- The development of this culture development needs to begin when the project is first conceived, and extend through design and construction into operation of the facility
- There are greater chances of successful operation if the building occupants and facility operational staff themselves are advocates for energy efficient building performance
- With a mindset of loving towards zero carbon the operational staff and occupants can be relied upon to provide ideas for increasing performance. If the occupants have not embraced the zero carbon culture, the chances of achieving zero carbon operations are significantly reduced.

1.2 Project Initiation

WIP

1.3 Design Reviews

WIP

Chapter 2. Process

Linking to the four step process in the previous chapter, this chapter describes an integrated design process that often uses energy modelling as a tool to explore demand reductions, efficiency increases, waste energy recovery and renewable energy deployment. It closes with a section on how recommended targets can be set to the deliver operational energy performance within the integrated design process. This process has applications to existing buildings, new facilities, and major renovations.

2.1 Integrated Design Process

Historically, facilities have been designed, constructed and commissioned using different teams in a linear fashion and with little to no integration between teams. While this process may be successful in less complex building projects, it rarely takes into account energy design considerations. This is a result of the

[9] Advanced Energy Design Guide for Small to Medium Office Buildings – Achieving Zero Energy. ASHRAE 2019.

teams responsible for these considerations being isolated from the rest of the project team and/or being brought in too late in this linear process.

The integrated design process can address this process gap. Some definitions of the process follow below:

> *A systematic and staged approach that ideally requires support from an interdisciplinary team of engineering, architecture and building science professionals. Working in concert, these professionals will optimize overall energy and cost savings from your project while enhancing the indoor environmental quality for your building occupants. (NRCan, 2016)*

> *An integrated process is highly collaborative. This approach requires the whole project team to think of the entire building and all of the systems together, emphasizing connections and improving communication among professionals and stakeholders--including user groups--throughout the life of a project. It breaks down disciplinary boundaries and rejects linear planning and design processes that can lead to inefficient solutions. (USGBC, 2014)*

These design processes that can lead to inefficient solutions may also lead to significant cost increases during the post-construction document stage, as illustrated by line 2 in Figure 2. In contrast, if effort is concentrated at the pre-construction document stage during pre-design, schematic design, and design development then the ability to impact cost and functional capabilities is much greater. This will likely lead to reduced cost of design changes, which is also shown by line 2.

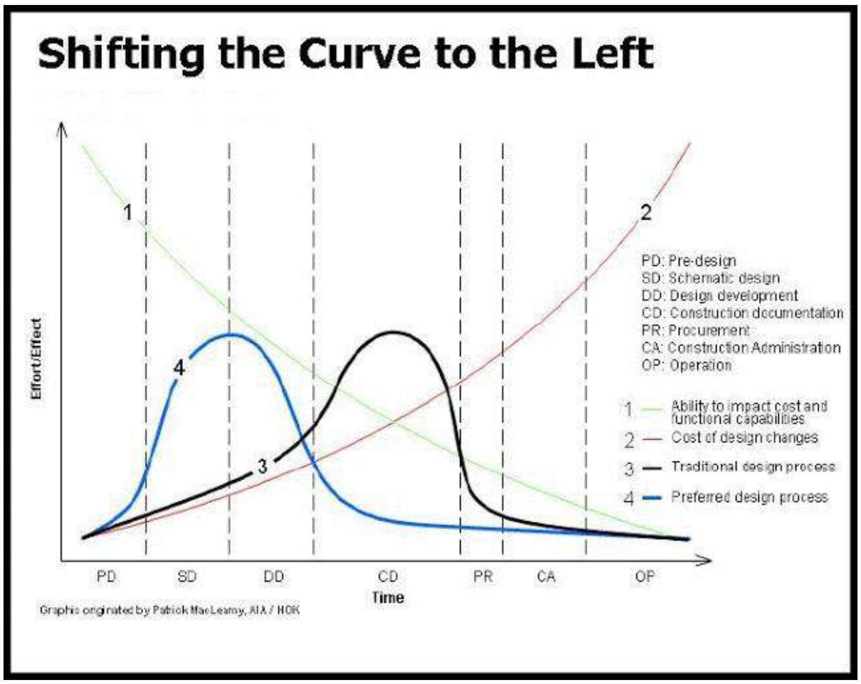

Figure 2 Shift in the Integrated Design Process

2.2 Energy Modelling

A common tool in the integrated design process is building energy modeling. Building energy modelling is a physics-based software simulation of energy use[10]. Some examples of inputs into this software include: building geometry, construction materials, HVAC, domestic and service water heating, lighting and control strategies. Controls strategies may also include schedules for occupancy, lighting, receptacle loads, and thermostat setpoints. The inputs are combined with local weather data and the program calculates heating and cooling loads, a response to those loads, and the resulting energy use. Other considerations such as thermal comfort and energy costs can also be determined by the program. The simulation is an hour by

[10] https://www.energy.gov/eere/buildings/about-building-energy-modeling

hour analysis and also accounts for interactive effects. One example is the interaction of pool water heat loss and evaporation with ambient temperature and relative humidity in an indoor setting.

Using energy modelling in the early stages of design—concept or schematic design—is recommended since it can quickly inform stakeholders on building massing and orientation that are favorable to high performance and occupant comfort. Once massing and orientation are established, mechanical and electrical systems can be added to the modelling mix to determine options that can meet energy targets as well as augment comfort. As system options are further evaluated and eliminated, a final model with fully developed systems can be created during the final stages of design development to confirm target and comfort compliance. This process can be used for energy code compliance and with high performance targets, code compliance should easily be met.

While the process outlined above is for new buildings, a similar process can be followed with existing buildings with the first step being model calibration to historical utility bill and energy sub-meter data so that its behaviour mirrors existing building energy consumption and demand. After this step, compliance with target and comfort goals can be determined.

2.3 Energy Targets

Energy targets for individual facilities are set based on the City of Brampton's Energy and Emissions Management Plan, which has an overall emissions reduction target of 20% by 2024 relative to a 2010 baseline for facilities where the City of Brampton is directly responsible for energy costs. Each facility target will contribute to the overall target and it is recommended that an early stage model be created during concept or schematic design.

To ensure that targets are met in design, construction and operation, individual targets are created for each facility and language for the target and early stage energy modeling are inserted into procurement documents in the case of new facilities and major renovations. The following sub-section is an example of this procurement language using moderate and higher performance targets, where moderate can be used as a minimum target. The language also details a format for an early stage energy model report including costs for different options.

2.3.1. Procurement Language

Provide early stage energy modelling with parametric analysis using a parallel coordinates plot to evaluate and illustrate the effect of building envelope, lighting, and HVAC parameters that influence both energy performance and occupant comfort. The use of tilt-unspecialized construction materials and methods is to be evaluated in the parametric analysis and to take into account thermal mass storage of building assemblies. The following parameters are to be used:

1. Window to wall ratio
2. Roof insulation
3. Wall insulation
4. Slab on grade insulation
5. Windows heat transfer
6. Overhead doors and door heat transfer
7. Window solar gain
8. Infiltration rate /air tightness
9. External shading percentage
10. Lighting system
11. HVAC system
12. Estimated Annual Energy Costs

This iterative energy modelling process is to generate data on energy consumption which will provide inputs for cost estimation.

The Zero Carbon Building Design Standard has Energy Modelling Guidelines that provides three approaches to demonstrate energy efficiency. The first approach provides the greatest flexibility for most projects, with requirements for thermal energy demand and overall energy use. The second approach recognizes projects that pursue more aggressive thermal energy demand reductions, putting additional emphasis on the building envelope and ventilation strategies. The third approach provides a path for projects that wish to achieve zero carbon in their annual operations without relying on purchased measures like carbon offsets or green power products such as a renewable energy certificates (RECs).

- **OPTION 1 Flexible Approach:** Thermal energy demand intensity (TEDI) of 30-40 kWh/m^2/year, as a function of climate zone; and site energy use intensity (EUI) 25% better than the National Energy Code for Buildings (NECB) 2017.
- **OPTION 2 Passive Design Approach:** Thermal energy demand intensity (TEDI) of 20-30 kWh/m^2 /year, as a function of climate zone.
- **OPTION 3 Renewable Energy Approach:** Thermal energy demand intensity (TEDI) of 30-40 kWh/m^2 /year, as a function of climate zone; and Zero carbon balance for operational carbon achieved without green power products or carbon offsets.

In addition to compliance with one of the above three options, the successful Proponent shall develop energy efficiency requirements as it relates to electricity consumption. These requirements shall minimize electricity use intensity so that when this intensity is combined with TEDI, the overall energy use intensity is 25% better than NECB 2017 as per Option 1.

Provide a report including:

- Data visualization graphic (parallel coordinates plot) with axes showing the effect of each of the eleven parameters listed.
- Estimated costing for building compliance, and the options discussed above
- Lifecycle payback for significant parameters
- Occupant comfort commentary on the relative merits of different envelope, lighting and HVAC systems on thermal and comfort performance of the facility. This commentary can be based on known industry studies.
- Overall comparison of options, a recommendation on which option to proceed with and how to integrate the bundle of parameters into the project.
- Highlight potential issues and risks associated with parameters.

2.4 Building Automation Systems

2.4.1. Building Automation Design Principles

The BAS Guideline design principles provides a high level description of the purpose and structure of the BAS Guidelines. This section includes the City of Brampton BAS design principles,

2.4.2. Integrated Design Vision

A Building Automation System is a series of networked controllers and a software headend designed to monitor and control the environment in a building. It controls all aspects of the HVAC and can extend to include lighting, sub-metering, security and more. It ensures the operational performance of the building systems as well as ensuring the comfort and safety of the building's occupants. The City of Brampton intends for its building automation systems to be an integral part of Energy Management by reducing energy consumption and GHG emissions.

Additionally, it is the goal of the city to shift design, construction and commissioning processes from a linear, individualized approach to an integrated and collaborated approach. It is the intention of this guideline that all aspects of the BAS design and implementation is considered holistically and applied through an iterative process. This involves looking at the interoperation of disparate systems and considering how these systems are to work together.

2.4.3. BAS Design Goals

As a Green City, Brampton has committed to zero carbon and high performance facilities. This commitment for A Zero Carbon Transition has been formalized through the City of Brampton's latest 5-year Energy and Emissions Management Plan for 2019-2024. The plan outlines the action plan to achieve a zero carbon transition for the City's new and existing corporate facilities. In accordance with the Paris Agreement, Brampton has adopted the provincial and federal greenhouse gas (GHG) emission reduction targets of 30% by 2030 and 80% by 2050, respectively, using a 2010 baseline. The federal target has since been updated to net-zero emissions by 2050 (re-affirmed by the Minister of Environment and Climate Change at the 2019 UN Climate Change Conference)[11]. The City has set an interim target of 20% GHG emissions reduction by 2024.

The design and implementation of Building Automation Systems is intended to support the three objectives of the Zero Carbon Transition Plan:

1. Minimize energy use
2. Minimize emissions
3. Maximize cost recovery

To achieve these 3 objectives, CoB has outlined **6 principles for the design of BAS**:

1. **Reliable control of systems which also includes alarms and trend logs must be provided in a BAS**
   The ultimate quality of a control system is primarily dictated by the components that sense, execute logic for, actuate and document the systems they are controlling[12]
2. **Require sufficient instrumentation** the designer is responsible for ensuring specified equipment will meet sequences.
   The designer must require instrumentation to support both the sequence of operations, and the data acquisition capability to support equipment performance monitoring and building diagnostics analysis. A listing generally establishing minimum instrumentation requirements is included with the specifications. This identifies minimum instrumentation for common types of system. The designer is responsible for requiring additional instrumentation as necessary to support the sequence of operations and necessary data acquisition capabilities.
3. **Environmental control for indoor conditions and some examples include: temperature, humidity and air quality**
   The measure of an environmental control system and how well it functions with other building wide systems is determined by occupant comfort, satisfaction, and well-being.
4. **Building wide and energy efficient control of systems and examples include: HVAC, envelope and lighting**
   A key measure of the system's energy management capabilities is its ability to communicate and exchange data with other building systems to achieve efficient and effective energy usage with consideration for GHG emissions and energy cost
5. **User friendly control which can be easily accessed and understood by operators**
   Ensuring ease of operations increases the usability of the BAS which leads to better operational performance. This also includes graphics that increase Energy Awareness through better designed and easier to understand graphics and public facing portals.

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[11] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html

[12] https://getrede.ca/five-principles-for-building-automation-systems/

6. **<u>Integration capable control</u> that can incorporate disparate systems together to operate as a whole**
   Examples of these disparate systems include but are not limited to BAS, metering, and security. This type of control is usually hosted on a software platform that can combine disparate systems

2.4.4. BAS Vendors

The following is a listing of approved BAS vendors for existing buildings. These vendors provide preventative and demand maintenance services for existing BAS systems at existing facilities:

1. Johnson Controls Canada LP
2. ESC Automation Inc.
3. Automated Logic Canada Ltd.

In 2020, the City of Brampton completed a prequalification process of BAS vendors to supply and install building automation systems (BAS) with native BACnet protocols. The prequalification enables pre-qualified vendors to bid on projects for a three (3) year period (currently up to December 31, 2023).

The types of projects will include: retrofitting existing buildings with new BAS, expanding BAS for existing facilities, and new BAS required for new construction facilities. Below is a list of prequalified vendors:

1. Johnson Controls Canada LP
2. ESC Automation Inc.
3. Siemens Canada

2.4.5. BAS Design Considerations

Design and construct Building Automation System (BAS) for building services with open protocol communications (BACnet).

New and existing installations use BACnet for all aspects of communication, including workstation, field panel, custom application controller and unitary controller communications and are commonly referred to as native BACnet systems.

When applicable, potential integration to be thoroughly discussed with City of Brampton.

The system shall allow for future integration of other systems (Card Access, Lighting, Intrusion Monitoring etc.) on the network proposed in this document, and also share a common infrastructure for network communications, time scheduling, alarm handling, history logging, monitoring and system control.

The system installed shall seamlessly connect devices other than HVAC throughout the building regardless of subsystem type (i.e. HVAC, lighting, and security devices should easily coexist on the same network channel without the need for gateways).

Sequences of operations should be designed and implemented to ASHRAE Guideline 36

Incorporate sequences that utilize energy conserving strategies. This includes, but is not limited to; demand based economizer control, supply air temperature reset, duct static pressure reset, occupant based demand control, chilled plant optimization control, boiler plant optimization control, free cooling control, etc. All major ventilation equipment to have a morning start-up and evening shutdown sequence. All equipment in manual over ride to switch back to automatic control after a stipulated time interval.

2.5 Archetypes

2.5.1. Community Centres

This section provides how-to strategies for the design and implementation of best practices applicable to classifications and facility archetypes (as referenced in Section 1.1). For this version of the guide, the following archetype is included:

- Community Centres with Indoor Pools
- Community Centres with Ice Rinks **(WIP)**
- Community Centre with Gymnasium & Fitness Areas **(WIP)**

Strategies specific to each facility archetype are provided for the following system categorizations:

- Building Envelope
- HVAC
- Lighting & Plug Loads
- Building Control and Automation

Strategies that apply to other programming and associated activities are also discussed within this chapter.

Community Centres – With Indoor Pools

Energy consumption in community centres with indoor pools is high due to high indoor air temperatures, increased ventilation heat losses and energy-intensive water technology. Energy consumed in swimming pool operation can be greatly reduced through a number of different best practices. These practices encompass: efficient operational procedures, program changes, use of alternative forms of energy, and energy efficient upgrades.

Building Envelope

Due to the humid and warm indoor climate, energy flows in swimming pool buildings are different from those in buildings with typical indoor conditions. These flows impact moisture control and the lack of moisture control may lead to unnecessary energy consumption by HVAC systems attempting to compensate from a poorly designed envelope. A key concept to control moisture is the dew point temperature. This temperature is the point at which moisture condenses out of the air. An example is when moisture condenses on the inside of a cold window in winter due to temperature and humidity differences. In an indoor pool environment, there is an elevated dew point temperature which means the potential for condensation is higher. This potential affects every aspect of the facility and thus, the building envelope must be designed to ensure the entire structure is suitable for a high-dew-point application. Some design measures that can be implemented for better moisture control are:

- Sufficient insulation such that no exterior wall and roof surface falls below the space dew-point temperature in cold weather
- Properly installed vapor retarder to impede the moisture flow through the wall assembly and protect the building envelope from condensation damage
- Thermally broken window and door frames and lower glazing U-values to decrease the transmission heat losses
- Better airtightness of the building envelope provides improved protection against moisture damage
- Airtightness tests should be scheduled in the construction process when essential elements of an airtight envelope and their penetrations are still easily accessible.
- Cooler gymnasium space types should be thermally separated from warmer areas of the building
- Kitchen spaces should be insulated from all sides due to the potential for moisture and high humidity

HVAC

Indoor Pool Water Temperatures and Relative Humidity

Indoor pools and spas require the relative humidity level be maintained between 40% and 60%.

The recommended pool water temperature for various activities are[13] :

- Recreational swimming: 82.5⁰F (28⁰ C)
- Infant swimming and therapy: 86⁰F -94⁰F (30⁰ C -34.4⁰ C)
- Children instructional classes: 84⁰F -90⁰F (29⁰ C -32.2⁰ C)

Competitive swimming and diving, including training and fitness swimming: 78 ⁰F -80.5⁰F (25.5⁰ C -27⁰ C)

Spas: 104⁰F (40⁰ C)

Ventilation

Space heating and ventilation accounts for a large proportion of energy use in pool halls which means that there are significant opportunities for savings. However, it is also important to ensure that the primary functions of the heating, ventilation and air conditioning system are satisfied. These are to comply with heating, cooling and outdoor air requirements as well as provide occupant comfort. Some recommended measures are:

- Ventilation air should be calculated as the minimum amount recommended as per the current ASHRAE Standard 62.1

- Pool areas should have a slight negative pressure to prevent the contaminated air from migrating into adjacent areas of the building[14]

- Where mechanical dehumidification is provided, air delivery rate should be established to maintain temperature and humidity level at appropriate conditions[15]. The following air change rates are recommended.

Pool areas	4 to 6 air changes per hour
Spectator areas	6 to 8 air changes per hour
Therapeutic pools	4 to 6 air changes per hour

Regarding indoor air circulation, the design must consider the following items[16]:

- Humidity control
- Ventilation requirement for air quality (outdoor and exhaust air)
- Air distribution
- Air duct design
- Evaporation rates
- Pool water chemistry

As with building envelope, poorly designed circulation may also lead to unnecessary energy use.

The balance between ventilation air and exhaust must always be controlled. Third-party commissioning should be performed to ensure the desired performance of the building is achieved.

In other areas of the building such as showers, changing rooms, lobby and staff rooms, demand control ventilation (DCV) based on moisture and/or CO_2 is suitable for reducing air flow volumes. The lower air flow

[13] Pool-Spa Operators Handbook-National-Swimming Pool Foundation 2009
[14] Pool-Spa Operators Handbook-National-Swimming Pool Foundation 2009
[15] Chapter 6 –Indoor swimming pools-2019 AHSRAE Handbook HVAC Applications
[16] Pool-Spa Operators Handbook-National-Swimming Pool Foundation 2009

volumes lead to reduced energy use. Also incorporate DCV strategy into other areas such as the gymnasium and kitchen. If feasible, consider heat recovery from kitchen exhaust air.

Heating Demand

It is advisable to examine on a project-specific basis whether it is feasible to use other types of waste heat (e.g. emitted by HVAC equipment) and solar heat for meeting the heating demand of the pool water.

The heating demand for domestic hot water (e.g. showers) depends on the distribution and storage losses as well as the amount of hot water required. Water-saving fixtures with controlled operating times for showers, and well insulated pipes form the basis for optimization. Due to the high waste water temperature of about 35 °C and frequent use, there is significant energy saving potential from heat recovery from the shower drain water.

Lighting & Plug Loads

Due to the longer operating hours and the larger spaces of indoor pools, the power requirement for lighting is often a significant energy end use. There are a number of measures that can used to minimize energy use:

- Efficient technologies such as LED that are suitable for higher temperatures
- Needs-based control strategies to reduce power consumption
- Natural daylighting from windows or roof skylights that can result in sufficient daylight to allow some artificial lighting to be switched off during the day
- For kitchen areas, clarify actual requirements and align these requirements with an appropriate cooking process that can also use high efficiency appliances.

Other Considerations

Other leisure activities are often offered in larger swimming pool facilities, resulting in additional energy consumption (e.g. kitchens, saunas, solariums, water attractions such as slides). In the case of water attractions, apart from the general optimization of pumps, it is possible to decrease energy consumption and peak loads by means of time-controlled operation (e.g. timers or intelligent controls).

- Insulate sauna cabins including additional roof insulation
- Use heat recovery and demand control ventilation for cabins, if separate ventilation units are being considered for saunas
- Operate at partial loads for pool water volumes to reduce power consumption, while complying with applicable codes and water quality requirements
- Explore solar water heating potential since solar water heating can be effective for showers and pool water and modern systems are relatively easy to connect to a conventional heating system
- Consider ventilation heat recovery and waste water heat recovery
- Replace aging conventional boilers with high efficiency condensing boilers
- Use pool covers which can reduce evaporation, thermal radiation, and convection accounting for about 95% of losses and
- Covers can also reduce dirt and debris in water which can result in reductions of chemical consumption[17]
- Check pipework regularly for leaks which can result in higher water consumption and heating costs
- Heating costs can also be reduced with properly insulated pipework and regular checks on the condition of insulation with replacement of damp or worn insulation
- Insulate boilers, hot water tanks, pipes and valves as required to prevent heat loss
- Schedule the cleaning work during the day, if possible so no additional energy is needed for lighting and ventilation

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[17] Pool-Spa Operators Handbook-National-Swimming Pool Foundation 2009

- Clean windows and skylights regularly to allow maximum daylight to enter the pool hall and significantly reduce the need for electric lighting
- The indoor air temperature should be kept 2F to 5F (1°C to 2.5°C) above the temperature of the pool water to reduce evaporation[18]
- Keep doors closed between areas with different temperatures and humidity.
- Conduct regular pool backwashing and clean the pool filters to maintain good quality clean water
- Inspect system components such as fans, coils and pumps for corrosion and clean or replace if necessary
- Replace aging conventional boilers with high efficiency condensing boilers
- Utilize premium or high efficiency pump and fan motors for water treatment and ventilation systems since reducing their electrical consumption can be a source of considerable savings

Control of Building Systems

Introduction

Control and automation systems work in concert with equipment, systems and staff to ensure high performance operation of facilities. In general, automation cannot fully compensate for poorly designed systems or inexperienced staff in terms of occupant comfort or energy efficient operations.

This section is intended to provide guidance and recommendations on energy efficient operations and occupant comfort for facility systems including HVAC equipment and lighting. These recommendations may be useful during the integrated design process to inform stakeholders on how control and automation can help to achieve energy targets and comfort goals The hand-over of building automation systems (BAS) that will meet these goals requires – at minimum – designers , commissioning agents, building operators to be included in the integrated design process.

The components, specifications and strategies of building automation systems are outlined in the following sections.

Building Automation Systems

- Provide a Building Automation System that includes Smart Control Devices, Programmable Controllers, and Application Specific Controllers as needed to perform functions indicated in the input/output summaries.
- The BAS shall be based on ASHRAE BACnet technology (ASHRAE Standard 135-2016) with an open communication protocol. The system shall be capable of remote communication over the City's intra-net network with a provided webserver.
- The addendum to ASHRAE Standard 135-2016 includes BACnet Secure Connection (SC). Consideration to this virtual data link should be investigated for building automation systems

HVAC Control Strategies

In general, the implementation of control strategies requires system equipment to be operated in a sequential manner. A sequence of operation is a descriptive and detailed account of system operation and usually includes such details as exact setpoints, precise alarm limits, scheduling and time-of-day details[19]. Where applicable sequences of operations are to be designed to the standard of ASHRAE Guideline 36 – High Performance Sequences of Operations for HVAC Systems (latest version).

A general strategy is to avoid simultaneous heating and cooling operation which can be achieved by interlocking heating and cooling controls. The following list are some strategies recommended by Energy Management:

18

19 http://www.pcs-engineering.com/files/Sequence_of_Operation_Instructions.pdf

- **Economizer Controls** save electrical energy by avoiding mechanical cooling. These are recommended to be provided for air handling equipment to use outdoor air for cooling instead of the mechanical cooling when outdoor conditions are favorable.

- **Variable Speed Drives** save electrical energy by allowing motors to run at lower frequencies. These are recommended to be provided on centrifugal pump motors, variable air volume fan motors and cooling tower pump motors. Variable speed drives are to be properly engineered with due consideration of harmonics, need for filters and interference with surrounding delicate instrumentation. The impact on power factor correction capacitors and protection from power surges and spikes must be evaluated. In a retrofit application the designer is responsible to determine whether speed control is appropriate and whether the selected technique is suitable for the existing motors configuration.

- **Heating Water Reset** allows water temperature to lower and saves natural gas as the water does always not need to be heated to the higher temperature. It is recommended to implement heating water reset when heating water is the main heat source for a space. Resetting heating water temperature based on the outside air temperature allows the water temperature to be raised in extreme cold applications and lowered in more mild conditions.

- **Duct Static Pressure Reset** allows fan speed to be lowered based upon zone demand, which saves electrical energy. It is recommended in situations in which there are multiple zones with VAV control. The duct static pressure can be reset satisfy zones with the highest airflow demand.

- **Outdoor Temperature Cut-off** saves energy in the form of natural gas when the heating system is turned off. It is recommended to be considered for heating systems so that heating is automatically shut off during unoccupied periods when outdoor air temperature is high enough that there is no risk to freezing items in the building.

- **Demand Control Ventilation** saves energy as it lowers the amount of unconditioned air being brought into the space based on the demand. It is recommended to be considered for air handling equipment. The outside air volume is modulated based upon the demand from the space as using CO2 instead of running at a designed constant outdoor air volume.

- **Scheduling of Equipment** ensure sequences have considered: start, stop, night setback, request based logic, and demand level adjustment of setpoints. All major ventilation equipment is recommended to be designed with a morning startup and evening shutdown sequence. If the facility is 24-hour or close to 24-hour occupancy consult with the design team prior to removing this functionality from design. All major ventilation equipment is recommended to be designed with a morning startup and evening shutdown sequence.

- **Pool Circulation Pump** saves electrical energy by allowing the pump to run at a lower rate when demand is lower. A pool circulation pump can be modulated based on demand. In this case demand can be determined by water turbidity. This strategy looks at the composition of the water to determine how much chlorine needs to be added and varies the pump speed based on this.

- **Temporary Manual Override** ensures that BAS systems are not left in manual override which can potentially waste energy. It is recommended to include a virtual timer for switch back to automatic control after a time interval selected by building operations staff.

- **Sequential lead/lag controls** helps to extend the life of the equipment. These controls are recommended to be provided where a bank of equipment services the same space. Lead equipment is recommended to cycle to provide equal wear and tear for all equipment. Examples are hot water heating boilers, domestic hot water boilers, chillers, associated pumps, cooling tower fans etc.

Table 1 lists control descriptions for specific systems and mechanical services. Where strategies may not be applicable, it is recommended that these strategies be reviewed with the with the City of Brampton design team including but not limited to Energy Management, Facility Operations and the Building Design and Construction Department during the design development stage.

Table 1 – BAS Control Descriptions

Equipment Description	BAS Function/Strategy
Pool circulation pump	Speed modulation based on turbidity
Pool water heater	Reset of pool heating water temperature based on usage
Unit Heaters	Programmable setpoint thermostats with occupancy override
Zone Control	Occupancy sensing to shut off constant volume or variable volume boxes plus lights.
Outdoor lighting	Schedule
	Trim schedule using photo sensor
	Trim schedule using sunset-sunrise calculation
Lighting	Schedule
	Photo sensor control
Exhaust fans	Schedule
	Occupancy override to schedule
Hot Water Boilers	Start/stop and modulated firing controls, minimize short cycling of heaters. Minimum runtime of 15minutes
	Reset water temperature.
	Boilers to run in lead/lag function switching weekly to ensure equal runtime. Alternatively, utilize boiler manufacture sequencer.
	Ensure complete modulating control or proper hi-low control.
	Maintain one setpoint and stage using time interval rather than error from setpoint.
	Stop circulating water through non-firing boilers.
DHW recirculation pumps	Start/stop based on weekly schedule with override based on flow switch

Equipment Description	BAS Function/Strategy
DHW	Start/stop and modulated firing controls, minimize short cycling of heaters.
	Schedule recirculation pump for occupied periods only
	Reduce setpoint to minimum required temperature
	Profile tank water temperature-lower temperatures will lower recirculation heat loss
	If tank separate from heater, do not circulate water through non-firing heater
	Maximize on-time by 1st on 1st off
Air systems	Supply air temperature reset from outside air temperature.
	Control outside air volume to occupancy requirement using CO2
	Trim supply air temperature setpoint with feedback from spaces.
	Mixed air control - calculate and control to minimum ventilation
	Integrated economizer (provide required supply air temperature)
	Scheduling - minimize scheduled time
	Scheduling - optimal start
	Scheduling - no outside air when systems operate in unoccupied hours
	Occupancy sensing - operate fan or open outside air dampers only when occupied
	Set relative humidity to as per ASHRAE guidelines,
	Reset humidity at very low temperatures
	Space pre-cool (morning)

Lighting Control

Lighting controls are important to ensure that lights are only on when they are necessary. Switch controls may allow lights to exceed their intended operating hours leading to unnecessary energy consumption. It is recommended by Energy Management that lighting systems be installed with controls to ensure operating hours are not higher than necessary.

- Occupancy Sensors are recommended to control lighting in areas of intermittent occupancy. Typical areas include meeting rooms, washrooms, locker rooms, change rooms and storage areas. Ultrasonic sensors are preferred.

Photocell Controls are recommended in large glazed areas that receive adequate natural lighting during the day. Peripheral can also benefit from day-lighting controls wired on separate circuits.

- Provide local switches in all offices, meeting rooms and spaces where building users can switch off lights when leaving the space. Larger spaces shall be divided into smaller zones of 10 to 12 light fixtures and controlled by a manual switch or computerized control.
- Lighting circuits for gymnasiums are recommended to be designed to provide 100%, 50% and 25% light levels with conveniently located master switches to allow for reduced light levels during periods of maintenance and non-use.
- Photocell and Timer Control are recommended on all external security lighting.

Refer to ASHRAE 90.1-2013, Table 9.6.1 for lighting control requirements for specific space types such as office spaces and stairwells.

- Lighting control systems shall seamlessly connect and be prepared for future integration with Building Automation Systems (BAS).

2.5.2. Transit Facilities

This section provides how-to strategies for the design and implementation of best practices applicable to classifications and facility archetypes (as referenced in Section 1.1). For this chapter, the following archetype is included:

Transit Facilities

Strategies specific to this facility archetype are provided for the following system categorizations:

- HVAC & Building Control and Automation
- Lighting

Strategies that apply to other programming and associated activities are also discussed within this chapter.

Introduction

HVAC Systems play an integral role in the safe and comfortable operation of Transit Facilities. A well designed and optimized HVAC system can allow for considerable energy savings. This section is intended to provide best practices for the design of a high performance HVAC system.

There main space types that this chapter will focus on:

- bus storage garages,
- bus maintenance garages,
- fueling & wash bays,
- associated office, lunch spaces, meeting and training rooms

Bus storage and maintenance garages use similar strategies to meet space temperature and ventilation requirements. The key difference between the storage and maintenance garages is maintenance garages should be kept at a higher temperature as maintenance garages are an occupied workspace compared to storage where occupancy is transitional. Fueling and washbays need to consider regulatory requirements to ensure appropriate ventilation for life safety.

Control and automation systems work in concert with equipment, systems and staff to ensure that high performance operation of facilities. In general, automation cannot fully compensate for poorly designed systems or inexperienced staff in terms of occupant comfort or energy efficient operations.

This section is intended to provide high level recommendations on how to improve energy efficient operations and occupant comfort for facility systems including HVAC equipment and lighting. These recommendations may be useful during the integrated design process to inform stakeholders on how control and automation can achieve energy targets and comfort goals. The hand-over of building automation systems (BAS) that will meet these goals requires an interdisciplinary team and all stakeholders to be included in the process as referenced in Chapter 3.0.

- Provide a Building Automation System that includes Smart Control Devices, Programmable Controllers, and Application Specific Controllers as needed to perform functions indicated in the input/output summaries.
- The BAS shall be based on ASHRAE BACnet technology (ASHRAE Standard 135-2016) with an open communication protocol. The system shall be capable of remote communication over the City's intra-net network with a provided webserver.

HVAC Control Strategies

In general, the implementation of control strategies requires system equipment to be operated in a sequential manner. A sequence of operation is a descriptive and detailed account of system operation and usually includes such details as exact setpoints, precise alarm limits, scheduling and time-of-day details[15]. Where applicable sequences of operations are to be designed to the standard of ASHRAE Guideline 36 – High Performance Sequences of Operations for HVAC Systems (latest version).
A general strategy is to avoid simultaneous heating and cooling operation which can be achieved by interlocking heating and cooling controls.

The following sub-sections provide HVAC and control strategies recommended by Energy Management for the typical space types found within transit facilities.

Storage, Maintenance Garage, and Fueling & Wash Bays

Transit storage and maintenance garages use similar strategies for conditioning air in the space. The key difference between these two spaces is not how the HVAC and control systems are designed but how they are operated. Storage garages are required to maintain buses at an adequate temperature to ensure winter start-up and provide shelter for the buses during unused hours. Maintenance garages, however, have more stringent requirements in terms of temperature setpoint and air circulation as they are occupied workspaces.

HVAC Design Considerations

- Design is recommended to consider heavy-duty industrial air curtains above overhead doors to minimize infiltration through open overhead doors.
- Where applicable, design to include high-speed exterior doors to achieve maximum environmental control and separation at the door opening. High-speed doors minimize exposure to outdoor conditions and minimize energy used to heat or cool outdoor air.
- In areas where feasible, incorporate radiant heating (potentially garage area). Radiant floor heating systems must be expandable without cutting the slab previously installed.[20]
- Investigate feasibility of geothermal systems to provide a source heating energy for radiant floor system.
- Investigate the feasibility of incorporating solar thermal to preheat domestic hot water systems.
- Due to the higher ventilation requirements in transit facilities, heat recovery can be significant when selecting air-handling systems. Designer should complete a thorough investigation of all available heat source and the feasibility to recover heat from all applicable equipment. It is recommended to ensure that supply and exhaust air streams are strategically located so that heat recovery can be easily implemented. Systems should be designed as well with the ability to bypass heat recovery so that free cooling can be implemented in the shoulder seasons. There may be additional structural considerations that should be investigated due to the weight of heat recovery systems.
- Install destratification fans to circulate conditioned air and/or move warmer air towards the occupied space during heating season.

[20] http://www.gosite.ca/engineering_public/DRM_Manual.pdf

- In spaces where radiant floor heating is impractical consider infrared radiant heaters since they warm only specific areas and objects and can be more efficient than air based heating systems.

Controls Considerations

- **Demand Limiting and Load Shifting** program for the purpose of limiting peak energy usage and reducing overall energy consumption, where applicable
- **Destratification Fan Control** meant to operate differently based on whether it is heating or cooling season. The BAS allows for seamless change over from heating to cooling based on outdoor air temperature.
- **Modulating Gas Valve** allows for slow ramping up and ramping down of burner on a roof top unit based on the demand for heating. This saves natural gas as a burner does not need to either in full heat or off.
- **Outside Air Temperature Reset** allows water temperature to lower and saves natural gas as the water does always not need to be heated to the higher temperature. This can apply to high temperature water or low temperature water used in radiant floor systems. It is recommended to implement heating water reset when heating water is the main heat source for a space. Resetting heating water temperature based on the outside air temperature allows the water temperature to be raised in extreme cold applications and lowered in more mild conditions.
- **Scheduling of Equipment** ensure sequences have considered: start, stop, night setback, request based logic, and demand level adjustment of setpoints. All major ventilation equipment is recommended to be designed with a morning startup and evening shutdown sequence. If the facility is 24-hour or close to 24-hour occupancy consult with the design team prior to removing this functionality from design. All major ventilation equipment is recommended to be designed with a morning startup and evening shutdown sequence.
- **Temporary Manual Override** ensures that BAS systems are not left in manual override which can potentially waste energy. It is recommended to include a virtual timer for switch back to automatic control after a time interval selected by building operations staff.
- **Sequential lead/lag controls** help to extend the life of the equipment. These controls are recommended to be provided where a bank of equipment services the same space. Lead equipment is recommended to cycle to provide equal wear and tear for all equipment. Examples are hot water heating boilers, domestic hot water boilers, chillers, associated pumps, cooling tower fans etc.

Associated Office, Lunch Spaces, Meeting and Training Rooms

Administrative spaces offer an opportunity for energy savings as they are not occupied 24/7 and they can be zoned more effectively than storage and maintenance garages. This allows for load matching sequences of operations to be implemented that provides better energy performance. Some examples demand control, and static pressure reset.

HVAC Considerations

- If the room is on an exterior wall, insulating glass shall be fully tempered tinted low-E glass
- Perimeter radiation is recommended and one example are baseboard heaters.
- All areas should be heated and air-conditioned by energy efficient, premium quality air handling units meeting the latest edition of ASHRAE 90.1 requirements.
- Investigate the feasibility of Variable Refrigerant Flow (VRF) technology with heat recovery option. There may be varying load applications which allow for energy savings in administration spaces.
- Designer should complete a thorough investigation of all available heat source and the feasibility to recover heat from all applicable equipment. It is recommended to ensure that supply and exhaust air streams are strategically located so that heat recovery can be easily implemented. Systems should be designed as well with the ability to bypass heat recovery so that free cooling

can be implemented in the shoulder seasons. There may be additional structural considerations that should be investigated due to the weight of heat recovery systems.

- If a more efficient technology is not feasible investigate high efficiency rooftop units (RTUs) that utilize condensing combustion technology. “Condensing heating technologies extract additional heat from combustion products by using a second heat exchanger to condense the water vapor produced. This additional heat exchanger allows condensing appliances to increase their thermal efficiency.”[21]

Controls Considerations

- **Economizer Controls** save electrical energy by avoiding mechanical cooling. These are recommended to be provided for air handling equipment to use outdoor air for cooling instead of the mechanical cooling when outdoor conditions are favorable.
- **Variable Speed Drives** save electrical energy by allowing motors to run at lower frequencies. These are recommended to be provided on centrifugal pump motors, variable air volume fan motors and cooling tower pump motors. Variable speed drives are to be properly engineered with due consideration of harmonics, need for filters and interference with surrounding delicate instrumentation. Ensure harmonic filters are installed if necessary to reduce the impact on power factor correction capacitors and protection from power surges and spikes must be evaluated. In a retrofit application the designer is responsible to determine whether speed control is appropriate and whether the selected technique is suitable for the existing motors configuration.
- **Duct Static Pressure Reset** allows fan speed to be lowered based upon zone demand, which saves electrical energy. It is recommended in situations in which there are multiple zones with VAV control. The duct static pressure can be reset satisfy zones with the highest airflow demand.
- **Outdoor Air Temperature Cut-off** saves energy in the form of natural gas when the heating system is turned off. It is recommended to be considered for heating systems so that heating is automatically shut off during unoccupied periods when outdoor air temperature is high enough that there is no risk to freezing items in the building.
- **Demand Control Ventilation** saves energy as it lowers the amount of unconditioned air being brought into the space based on the demand. It is recommended to be considered for air handling equipment. The outside air volume is modulated based upon the demand from the space using CO2 levels instead of running at a designed constant outdoor air volume.

Table 2 lists control descriptions for specific systems and mechanical services. Where strategies may not be applicable, it is recommended that these strategies be reviewed with the with the City of Brampton design team including but not limited to Energy Management, Facility Operations and the Building Design and Construction Department during the design development stage.

Table 2 – BAS Control Descriptions

Equipment Description	BAS Function/Strategy
Infrared Heaters	Programmable setpoint thermostats with occupancy override and configurable nighttime setbacks.
Unit Heaters	Programmable setpoint thermostats with occupancy override and configurable nighttime setbacks.
Zone Control	Occupancy sensing to shut off constant volume or variable volume boxes plus lights.
Outdoor lighting	Schedule

[21] https://www.gti.energy/wp-content/uploads/2018/11/Condensing-Roof-Top-Units-Technology-Snapshot-02-2017.pdf

Equipment Description	BAS Function/Strategy
	Trim schedule using photo sensor
	Trim schedule using sunset-sunrise calculation
Lighting	Schedule
	Photo sensor control
Exhaust fans	Schedule
	Occupancy override to schedule
Hot Water Boilers	Start/stop and modulated firing controls, minimize short cycling of heaters. Minimum runtime of 15minutes
	Reset water temperature.
	Boilers to run in lead/lag function switching weekly to ensure equal runtime. Alternatively, utilize boiler manufacture sequencer.
	Ensure complete modulating control or proper hi-low control.
	Maintain one setpoint and stage using time interval rather than error from setpoint.
	Stop circulating water through non-firing boilers.
DHW recirculation pumps	Start/stop based on weekly schedule with override based on flow switch
DHW	Start/stop and modulated firing controls, minimize short cycling of heaters.
	Schedule recirculation pump for occupied periods only
	Reduce setpoint to minimum required temperature
	Profile tank water temperature-lower temperatures will lower recirculation heat loss
	If tank separate from heater, do not circulate water through non-firing heater
	Maximize on-time by 1st on 1st off
Air systems	Supply air temperature reset from outside air temperature.
	Control outside air volume to occupancy requirement using CO2 (other gases)
	Use of modulating
	Trim supply air temperature setpoint with feedback from spaces.

Equipment Description	BAS Function/Strategy
	Mixed air control - calculate and control to minimum ventilation
	Integrated economizer (provide required supply air temperature)
	Scheduling - minimize scheduled time
	Scheduling - optimal start
	Scheduling - no outside air when systems operate in unoccupied hours
	Occupancy sensing - operate fan or open outside air dampers only when occupied
	Set relative humidity to as per ASHRAE guidelines,
	Reset humidity at very low temperatures
	Space pre-cool (morning)

Lighting

Lighting is an important consideration in transit facilities as safety is of paramount concern. Lighting should be designed to provide clear paths throughout the facility while considering energy efficiency. The large areas requiring high lighting levels allows for opportunities to demonstrate energy efficiency.

- Install LED light fixtures in all areas. The levels and quality of lighting for the various types of areas shall be as outlined to meet the latest edition of the Illuminating Engineering Society of North America (IES) Lighting Handbook, Ontario Building Code and Ontario Electrical Safety Code.

Lighting controls are important to ensure that lights are only on when they are necessary. Switch controls may allow lights to exceed their intended operating hours leading to unnecessary energy consumption. It is recommended that lighting systems be installed with controls to ensure operating hours are not higher than necessary.

- Ensure occupancy sensors are to be provided in the following areas: bus storage garage, service rooms, outdoor lighting, offices and other areas as required. Ultrasonic sensors are preferred.
- The interior design should promote natural daylighting. Maximize the use of natural light by using photo sensor and /or daylight harvesting controls and dimming in large glazed areas that receive adequate natural lighting during the day. Peripheral can also benefit from day-lighting controls wired on separate circuits.
- Provide local switches in all offices, meeting rooms and spaces where building users can switch off lights when leaving the space. Larger spaces shall be divided into smaller zones of 10 to 12 light fixtures and controlled by a manual switch or computerized control.
- Photocell and Timer Control are recommended on all external security lighting.
- Refer to ASHRAE 90.1-2013, Table 9.6.1 for lighting control requirements for specific space types such as office spaces and stairwells.
- Lighting control systems shall seamlessly connect and be prepared for future integration with Building Automation Systems (BAS).

2.5.3. Corporate Office Facilities

WIP

2.5.4. Library

WIP

2.5.5. Fire Station

WIP

Section III. Implementation

This implementation section is intended to provide recommendations to implement the design of zero carbon or high performance energy facilities. This section applies to new construction and major renovation projects that are City owned or managed.

This section is a WIP.

Section IV. Operations

Chapter 1. Purpose

1.1 Purpose

The Operations section of the EM Guide & Compendium provides recommendations for the operation of zero carbon or high performance facilities. This section applies to all existing and new construction facilities that are City owned or managed.

The targeted audience for this section is the facility operational staff within the following organizational groups:

- Facilities Operations & Maintenance
- Recreation
- Transit
- Fire and Emergency Services
- Public Works and Engineering

This section provides an overview of operation processes, followed by customized facility operation strategies for various facility archetypes with a focus upon best operational practices and setpoints/schedules.

1.2 Operation of Zero Carbon and High Performance Facilities

One of the most cost-effective strategies for ensuring optimal equipment performance and maximum building efficiency is effective facility operation. Operations are services required to ensure equipment and systems are operating as designed or at a level that achieves the facility management team's operational goals. The operational phase of a commercial building is substantially longer than its design and construction phase. 60% to 85% of a building's total lifecycle cost is attributed to by the lifecycle cost of the operational life, where as 5% to 10% is comprised from the design and construction.

It is necessary to practice systems-thinking, for both building systems and organizational systems, in order to achieve successful high performance facility operation. Operating facilities at high performance involves proactive management processes for energy, emissions, and maintenance.

Chapter 2. Process

2.1 Facility Startup

WIP

2.2 Energy Efficiency vs. Energy Conservation

Throughout this section there are references to the terms *energy efficiency* and *energy conservation*. These terms are closely related as they are both used to describe specific mechanisms for reducing energy consumption, however the differences between energy efficiency vs energy conservation should be noted.

Efficiency and conservation are different, but related[22]:

- **Energy efficiency** is using technology that requires less energy to perform the same function. Using a light-emitting diode (LED) light bulb that requires less energy than an incandescent light bulb to produce the same amount of light is an example of energy efficiency.

[22]Use of energy explained: Energy efficiency and conservation (https://www.eia.gov/energyexplained/use-of-energy/efficiency-and-conservation.php Accessed April 2020)

- **Energy conservation** is any behaviour that results in the use of less energy. Turning the lights off when leaving the room and recycling aluminum cans are both ways of conserving energy.

2.3 Operator and Tenant Engagement

The success of all energy efficiency initiatives depends on people as much as or even more than technologies implemented within a facility. To maximize the energy savings and emissions reduction potential of all COB managed facilities, it is important to raise the awareness of everyone involved, including operational staff, tenants, and all facility occupants and visitors.

Technology alone cannot achieve optimal savings; changes in operations and maintenance practices, as well as management systems, are integral in achieving significant savings. The figure below illustrates how organizational, technological and behavioural change interact with each other as a continuous, dynamic process. Integrating an energy management culture with operational and technological actions is required for optimal results. Employee behaviour is also crucial because it puts people in the "feedback loop" and is supported by celebration and recognition of results.

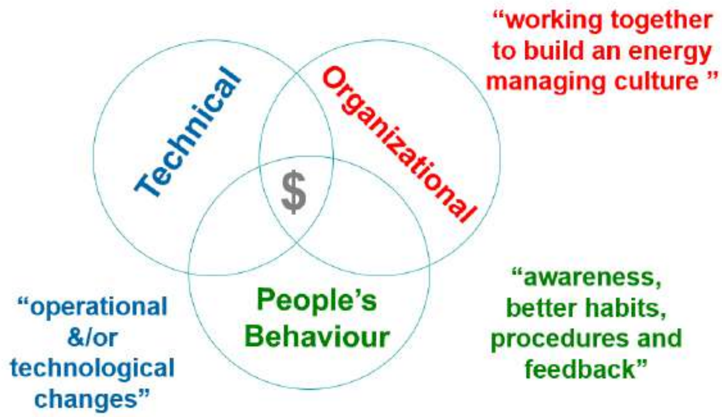

Figure 3 - The Challenge is more than technical[23]

Major benefits of operator and tenant engagement on energy efficiency and energy conservation include:

- increased thermal comfort levels from optimal temperature control management and the reduction of employee eye strain caused from inefficient lighting is shown to be linked to increased productivity in the workplace[24]
- collaborating to achieve a common goal can lead to enhanced employee morale
- lowered GHG emissions and air pollutants can lead to an improved environment which benefits human health as air pollutants and rising temperatures are linked to respiratory and cardiovascular problems and certain types of cancers[25]
- increased stakeholder understanding of energy efficiency advantages can lead to greater acceptance of future energy initiatives
- having an increased understanding of relationship between an individual's energy use and potential savings can allow employees to independently identify energy savings opportunities

[23] Dollar to $ense Workshop Training, CIET (2019)

[24] Loftness, et al. "Linking Energy to Health and Productivity in the Built Environment." Center for Building Performance and Diagnostics, Carnegie Mellon, 2003.

[25] Greenhouse gas emissions: drivers and impacts (https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions-drivers-impacts.html Accessed April 2020)

- learning about behavioural changes in building users' energy consumption can lead to the transfer of workplace behaviours to the home and community
- achieving our energy targets can lead to the enhanced reputation of our municipality as a local leader in environmental stewardship
- an energy management philosophy integrated into policy and processes across the organizational structure, with delegated responsibilities clearly outlined, can lead to a solid foundation for future initiatives

To create a culture of energy conservation and to provide operational staff with the tools necessary for managing high performance facilities, the EM team encourages participation in the following EM organized activities/events:

- Dollars to $ense Energy Savings Program
- Energy Conservation Challenge Program
- Technology Specific Training Sessions

Operational staff and tenants are also encouraged to identify additional training opportunities and think critically about the following questions:

1. How does my building use electricity and natural gas and contribute to the City's energy costs
2. How does my building use electricity and natural gas and contribute to City's overall GHG emissions?
3. What are some common actions that I can take to reduce energy and emissions within my facility?
4. What are some creative ways to save both natural gas and electricity and how can I involve the City's EM team in implementing my ideas?

2.4 Organizational Communication

To truly operate and maintain a high performance facility requires the synthesis of people, process and technology using a systems-thinking approach. This requires knowledge transfer from different areas of expertise, including but not limited to the following organizational groups:

- Energy Management (EM)
- Asset Management & Capital Planning
- IT
- Building Design & Construction
- Realty Services

In order to facilitate a strong working relationship between EM and operational staff for City owned and managed facilities, it is important to ensure clear and consistent communication regarding any operational changes that may impact a facility's energy consumption. This includes but is not limited to the following potential changes:

- Equipment Purchases
- Schedule
- Operational Staff
- Occupancy
- Building Control and Automation
- Facility Programming or Shutdown Periods
- Construction

2.5 Utility Bill Review

On an annual basis, the City's Corporate Performance Team tracks KPIs for energy usage and energy intensity (usage per unit area) within City owned and managed facilities. In addition to this, under O.Reg 507/18, all Ontario public agencies must report their annual energy use and greenhouse gas emissions each year by July 1. The City of Brampton must comply with this regulation as a municipality.

It is recommended that operational facility staff review their utility bills for electricity, natural gas, and water to understand the charges and to assist the Energy Management team in identifying and resolving any utility bill anomalies. These anomalies may be caused by a number of reasons including but not limited to changes in day-to-day facility operation (as discussed in the previous sub-section), phantom loads (devices that continue to consume energy even when turned off), malfunctioning utility meters, malfunctioning facility equipment, or billing errors.

All facility operational staff have a role to play in managing energy usage to meet Corporate Performance team targets to minimize energy usage and energy intensity across City facilities. Keeping engaged and aware of your facility's monthly utility costs is one of the actions that can lead to the more timely identification of these types of errors and the identification of energy efficiency and conservation opportunities.

2.6 Thermal Comfort Considerations

One of the main purposes for the operation of high performance facilities is to provide thermal comfort for a particular facility within in a particular climate. Thermal comfort and providing a productive, safe and healthy indoor environment cannot be sacrificed to save energy. It is important to maintain a balance between energy efficiency, energy conservation and thermal comfort to ensure that efficiency and conservation efforts do not affect thermal comfort of the facility occupants.

Thermal comfort is a subjective assessment by a person expressing their satisfaction with their local thermal environment. In practice, there are a number of variables that influence the body's heat balance with the environment, and in turn that person's perception of thermal comfort, including the following:

Table 3 – Factors Affecting Thermal Comfort

Personal Factors	Environmental Factors
• Occupant Activity • Clothing • *Age* • *Gender* • *Health* • *Culture* • *Personal control, and expectations.*	• Air temperature • Air Velocity • Radiant temperature • Humidity

Air temperature is a key environmental factor for determining thermal comfort. However, temperature is not the only factor, and other factors affect the processes of heat exchange on the human body such as humidity, air velocity, and radiation. The environmental factors presented above are measurable variables, as are occupant activity and clothing from the list of personal factors however it should be noted that the additional personal factors affecting a particular individual body heat balance or response to their environment are difficult to measure including but not limited to age, gender, health, culture, personal control, and expectations.

To determine if building occupants are comfortable, operational staff are encouraged to employ the following basic approaches:

- Monitor the number of comfort complaints (hot/cold calls) logged for the building or certain areas of a building

- Perform a comfort survey of all building occupants

For a more advanced approach in meeting thermal comfort needs, details can be found within *ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 55, "Thermal Environmental Conditions for Human Occupancy,"* a recognized industry standard providing guidance on thermal comfort parameters for building occupants. This guide provides details regarding Predicted Mean Vote' (PMV) and adaptive comfort criteria.

PMV thermal comfort criteria is an approach whereby a band of interior temperature and humidity ranges is prescribed to meet the needs of a minimum of 80% of building occupants. This approach was developed in laboratory settings, where people were passive recipients of environmental stimuli and not visually or thermally connected to the outdoor environment, or provided with thermal controls in their environment (e.g. operable windows). For naturally ventilated spaces, where the occupant has access to and control of an operable window, the more recent adaptive thermal comfort regimen recognizes that a wider range of interior temperatures can be acceptable for occupants, particularly where occupants will adapt to changing exterior conditions and dress in accordance. In adaptive comfort conditions, interior temperatures vary to allow for slightly higher interior temperatures in the warmest periods of the year, and slightly cooler for cooler periods of the year.

2.7 Domestic Hot Water Considerations

High performance Domestic Hot Water (DHW) considerations are consistent throughout most operational archetypes.

Best Operational Practices

- ❖ Ensure tanks are properly insulated
- ❖ Follow best practice maintenance guidelines from manufacturer
- ❖ Ensure hot water pipes are insulated appropriately

Best Practice Set-Points

Although ASHRAE Standard 100-2006 recommends a domestic hot water temperature of 49°C (120°F), organizations such as the Canada Safety Council and Canadian Standards Association (CSA) state that a common bacteria, legionnaire's disease bacteria, has a high risk of colonization in hot water tanks between 40°C and 50°C (104°F and 122°F)[26]. Therefore, in order to be energy efficient and lower the risk of scalding and bacteria growth, the following temperature settings listed in Table 4 are recommended.

Table 4 – Best Practice Domestic Hot Water Temperature Settings[26]

Setting Type	Temperature (°C)	Temperature (°F)
Storage Tank Temperature	60	140
Delivery Temperature	49	120

2.8 New or Innovative Technology Considerations

Advanced technologies found in high performing facilities may cause challenges to building operators and facility managers. These challenges arise when operators, technicians, and managers do not have the opportunity to learn about the specialties of high performance technologies.

For the parties involved, a feedback loop is appropriate for communication of what systems and equipment are working as intended and where further improvement is required. A feedback loop for high performance facilities is particularly essential since specialized technologies are not standard practice, leading to several, and at times conflicting, opinions on which systems and equipment should be used in these facilities.

[26] Canada Safety Council (https://canadasafetycouncil.org/heated-debate-about-hot-water/ Accessed April 2020)

Installing highly energy efficient systems and equipment creates only the foundation for achieving efficient, high-performance operation. Moreover, the processes implemented to operate and maintain these buildings have a larger cost and environmental impact that the design and construction process.

Energy Management has been adopting new technologies for energy savings and operational efficiencies. In 2019, a pilot project was completed that involved using proprietary cartridges in the closed chilled water loop at Civic Centre. The preliminary results of this pilot appear to have yielded energy savings.

If your facility is selected for a technology pilot project it is expected that operations will collaborate with Energy Management to ensure that the pilot is completed successfully. This may include site visits, training on new technologies, data collection and analysis, and other tasks related to project coordination.

Chapter 3. **Operations by Archetypes**

This chapter presents the operational considerations by archetype. For each archetype the following details are provided:

- **Best Operational Practices:** This sub-section provides suggested tips and guidance for the efficient operation of the particular facility archetype. For community centres, these tips are provided for specialized operations. For all other facility types these tips are categorized into the following categories: Behaviour, Operations and Maintenance HVAC, Plug Loads, Lighting.
- **Best Practice Set-Points:** This sub-section provides recommended occupied and unoccupied temperature set-points including set-points for specialized operations.

3.1 Community Centres

Community Centres are comprised of the largest energy users for the City of Brampton (and most municipalities in general). These are typically complex facilities that can include combinations of indoor swimming pools, ice rinks, gymnasiums and fitness areas, and public meeting spaces. These combinations usually with longer operating hours present unique opportunities for significant energy and cost savings.

In this section the community centre archetype is further broken down into the following use categorizations:

- Pool
- Ice Rink
- Gymnasium & Fitness Centres
- Administrative Spaces, Community Room, and Common Areas

3.1.1. Pool

Indoor pool facilities are energy intensive spaces and have specialized environmental requirements, due to the need to provide comfortable pool water and surrounding temperatures for user groups and also to avoid poor air quality and potential damage to the building envelope due to condensation. The equipment within these spaces is operated and maintained in a manner to promote address the aforementioned two points. The optimized operation of pool facilities requires a balance of pool temperature, air temperature, and humidity; a small change in any of these factors can impact the balance, causing major energy and comfort impacts. Additionally, operational issues caused by HVAC equipment can lead to unnoticed excessive energy use, such as using excessive amounts of outside air and the breakdown of heat-recovery equipment. The combination of the number of facilities, energy-intensity, and sensitivity of energy use in several equipment leads to a substantial and achievable cost-effective savings potential in indoor pool facilities[27].

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[27] Operator's Guide to Energy Efficient Indoor Public Pool Operations (http://mn.gov/commerce-stat/pdfs/card-guide-pool-operations.pdf Accessed April 2020)

Best Operational Practices

The following list of best practices provides energy efficient considerations for high performance pool operations[27]:

- ❖ **Test and Verify Control Systems:** For controls systems related to the below points it is recommended that operations teams make efforts to verify the functionality of the control systems. Some warning signs may be present if there are issues with the sequences of operations. For dehumidification systems an issue with the sequences can lead to condensation build up. If operational staff notice major issues persisting reach out to the appropriate internal manager and Energy Management Supervisor. Subject to approval, contact controls and mechanical contractors for further investigation. Contractors are to ensure that controls systems are performing as per manufacturers specifications.
  - Humidity Control: Outdoor air conditions are often favourable for free dehumidification. There is an opportunity to dehumidify pools by using dry outdoor air. This can be done by proper setup of the dehumidification unit and verification by the service provider.
  - Schedule pool equipment properly:
    - Reduce pool water temperatures based on the type of activity**.**
    - Turn off special pool features such as slides when not needed**.**
- ❖ **Ventilation Requirement for Air Quality (Outdoor and Exhaust Air)**: Ensure outdoor air damper is functioning properly as per design with a manual check of the damper position. See below ventilation section for further information regarding air changes in pool areas.
- ❖ **Evaporation Rates:** See Table 5 for settings to reduce evaporation. Reducing evaporation helps to decrease the amount of makeup water necessary and reduces the load on the pool dehumidification unit.
- ❖ **Reduce Makeup Water**
  - Backwash pool filters only when necessary
  - Ensure lifeguards are trained to reduce splashing from bathers to reduce makeup water.
  - Check to ensure the pool is not above user load capacity and that makeup water is being added based on an accurate bather load.
  - If feasible, use pool cover to reduce evaporation rate and associated makeup water.
- ❖ **Ensure appropriate operations and maintenance activities are completed as per manufacturers schedules**
  - Check that heat recovery units are operating properly. Have service contractor ensure proper operations.
  - Ensure regular cleaning and replacement of pool filters
  - Check that all pool boilers are functioning properly
  - Verify sequences of pool dehumidification unit and ensure operations are as per designed intent

❖ **Manage Shower Water Temperature**

- "The shower water system shall have one or more tempering devices capable of being adjusted to ensure that water supplied to shower heads does not exceed 40°C."[28]

Best Practice Set-Points

The recommended pool water temperature for various activities are:

Table 5 – Best Practice Water Temperature Settings for Pools[29]

Type of Pool	Air Temperature °C (°F)	Water Temperature °C (°F)
Recreational	23.9 to 29.4 (75 to 85)	23.9 to 29.4 (75 to 85)
Therapeutic	26.7 to 29.4 (80 to 85)	29.4 to 35 (85 to 95)
Competition	25.6 to 29.4 (78 to 85)	24.4 to 27.8 (76 to 82)
Elderly Swimmers	28.9 to 32.2 (84 to 90)	29.4 to 32.2 (85 to 90)
Whirlpool/Spa	26.7 to 29.4 (80 to 85)	36.1 to 40 (97 to 104)

"To minimize evaporation and operating costs, the air temperature should be kept as warm as is practical, ideally at or above the water temperature, with a maximum of 86°F db, which is generally understood to the maximum for human comfort. "[29]

According to the National Swimming Pool Foundation, adjusting the water temperature 0.5°C (1°F) can save up to 10% in energy cost savings.

Controlling humidity levels reduces the risk of mold, corrosion, structural damage and an uncomfortable pool environment. According to Department of Energy (DOE), adjusting the pool space temperature 1.5°C to 5.5°C (3°F to 10°F) can save 5% to 12% in energy cost savings.

The recommended humidity settings for pool facilities are

Table 6 – Best Practice Humidity Settings for Pool Facilities[29]

Season	Humidity (%)
Summer	50 to 60
Winter	50 to 60

Pool Ventilation

Space heating and ventilation accounts for a large proportion of energy use in pool halls which means that there are significant opportunities for savings. However, it is also important to ensure that the primary functions of the heating, ventilation and air conditioning system are satisfied. These are to comply with heating, cooling and outdoor air requirements as well as provide occupant comfort. Some recommended measures are[30]:

- Ventilation air is recommended to be calculated as the minimum amount recommended as per the current ASHRAE Standard 62.1
- Pool areas are recommended to have a slight negative pressure to prevent the contaminated air from migrating into adjacent areas of the building[30]

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[28] Ontario Regulation Building Code (https://www.ontario.ca/laws/regulation/120332 Accessed April 2020)
[29] 2019 ASHRAE Handbook HVAC Applications – Chapter 6 – Indoor Swimming Pools
[30] Pool-Spa Operators Handbook-National-Swimming Pool Foundation 2009

- Where mechanical dehumidification is provided, air delivery rate should be established to maintain temperature and humidity level at appropriate conditions. The following air change rates are recommended:

Table 7 – Recommended Air Change Rates for Pool Ventilation[29]

Area	Air Change Rates
Pool areas	4 to 6 air changes per hour
Spectator areas	6 to 8 air changes per hour
Therapeutic pools	4 to 6 air changes per hour

3.1.2. Ice Rink

A significant amount of electricity is required to run an ice rink facility, typically ranging from 300,000 kWh for a single sheet seasonal area to 970,000 kWh for multi-sheet, extended season facilities[31]. The energy savings that an ice rink facility contributes substantially impacts the City utility's budget because of their high building and operating costs.

The main energy and environmental requirements in an ice rink facility are:

- Creating and maintaining the ice surface.
- Providing a comfortable environment for facility staff and occupants.
- Heating to appropriate levels in different facility areas for spectators, administrative offices, eating and change rooms, and maintenance areas
- Providing hot water for showering and ice resurfacing where hot ice resurfacing is used.
- Lighting to appropriate levels in various facility areas for different activities and areas
- Delivering good air quality in the different areas of the facility
- Providing kitchen facilities with the capabilities to provide food for both spectators and staff
- Optimizing dehumidification to avoid potential condensation on the ice and various facility activity areas

Upholding these requirements requires financial commitment since energy consumption is directly proportionate to energy costs of an ice rink facility. Thus, to reduce the building and operating costs, reducing the facility's consumption is essential. This can be accomplished through proper system design that will maintain high-quality ice and operations.

Best Operational Practices

The following is a list of some steps to consider to reduce the energy consumption in the ice rink facility[31]:

- ❖ **Test and Verify Control Systems:** For controls systems related to ice rinks including dehumidification and rink controllers it is recommended that operations teams make efforts to verify the functionality of the control systems. Some warning signs may be present if there are issues with the sequences of operations. For dehumidification systems an issue with the sequences can lead to condensation build up. If operational staff notice major issues persisting reach out to the appropriate internal manager and Energy Management Supervisor. Subject to approval, contact controls and mechanical contractors for further investigation. Contractors are to ensure that controls systems are performing as per manufacturers specifications.

[31] Refrigeration Manual: Ice Rink Applications published by Ontario Recreation Facilities Association (ORFA), 2008.

- ❖ **Lower Resurfacing Water Temperature:** Rink resurfacing water temperature can be lowered from the standard setting of 180°F (82°C) to between 130°F and 140°F (54°C and 60°C) while still maintaining the ice surface quality. This saves money and energy by reducing the amount of energy required to raise the temperature of the resurfacing water and reducing the refrigeration load of the ice surface.
- ❖ **Raise Secondary Refrigerant Temperature**: The secondary refrigerant circulating beneath the ice surface absorbs heat from the concrete slab and ice surface and carries it away. To accomplish this, the secondary refrigerant must be colder than the ice surface. If it becomes colder than needed, the compressor will have to work harder than required to maintain this heat exchange process. Optimum secondary refrigerant temperature for both occupied and unoccupied periods for the average Canadian ice rinks are 15 to 18°F (-9.40°C to -7.8°C) for occupied periods and 18 to 22°F (-7.8°C to -5.5°C) for unoccupied periods. A temperature increase 2 to 3 degree Celsius during unoccupied periods and small increase of 1 to degree during occupied periods reduces compressor energy consumption by a substantial amount. To implement nightly ice temperature set up, the facility refrigeration system must be capably of decreasing the temperature from the non-occupied setting swiftly in the morning for occupied periods.
- ❖ **Optimize Ice Thickness:** Maintaining the ice thickness at an optimal thickness of between 1 to 1.5 inches (25.4 and 38.1 mm) requires less energy consumption by the refrigeration system. Optimizing the ice thickness reduces the load on the refrigeration system, resulting in an increase of the refrigeration system’s overall capacity. The equipment’s life expectancy is also increased because of less mechanical work and increased efficiency. Several factors affect the optimal ice thickness for a particular rink, such as the capacity of the refrigeration system and the usage pattern of the ice rink. Some trial and testing will be necessary to determine the optimal ice thickness for each rink. In most arenas, reducing the energy used by the refrigeration system results in a reduction of the amount of heat recoverable by the space heating system. To balance the lowered cost of refrigeration with a higher cost of HVAC, the services of a qualified refrigeration engineer are necessary.
- ❖ **Optimize Ventilation:** Indoor air quality an important feature for ice rink facilities since proper ventilation is critical at all times. Conversely, an abundance of ventilation results in an increase in energy consumption towards running the fans, an increase in heating and dehumidification demands, and an increases the heat load on the ice surface without any improvement in air quality. Optimizing ventilation results in a double benefit of a reduction in energy required to operate the ventilation system and a reduction of conductive transfer of heat from the air to the ice sheet caused by lower rates of air change.
  - There are three means of optimizing ventilation:
    - o Shutting down the ventilation systems when facility is vacant and air quality is not a critical issue
    - o Install carbon dioxide and carbon monoxide sensors (to monitor indoor air quality linked to the HVAC system to match the ventilation system operation to actual indoor air requirements as outlined by legislated regulations.
    - o Minimize ventilation requirement by using weather-stripping to restrict the entry of humid air.
- ❖ **Optimize Dehumidification:** It is vital to control humidity levels in ice rink facilities, especially during warmer seasons. An excess of moisture results in poor ice quality caused by

condensation, which also causes an additional load on the refrigeration system. It also leads to building degradation through condensation, mold and impacts the comfort of customers. Many existing technologies are able to dehumidify the air. Assistance from an HVAC engineer will be required to choose the best dehumidifier technology.

- **Management of Electrical Power Demand:** Management of electrical power demand lowers a facility's peak demand, avoiding peak demand charges. Facility operators can administer the peak demand by implementing the following changes;
  - Reschedule operations to avoid running equipment at the same time, including overlooked equipment such as kitchen equipment, coffee makers, computers, printers and office lights.
  - Shut down non–essential equipment
  - Replace older, inefficient motors with new high efficiency motors that use less energy at the same horsepower rating and load.
- **Optimize Compressor Operation (Compressor Sequencing):** The compressor is the largest energy consumer in a refrigeration system. With appropriate design and proper operation of the compressor configuration, savings of up to 15% are possible. To achieve energy efficiency, it is necessary to choose the optimal configuration of compressor type and sizes for a specific facility, such as multiple units operating in sequence with only the most efficient compressor operating at any point in time. Optimizing the operation and using only one compressor when necessary extends the equipment life cycle while also minimizing maintenance costs.
- **Optimize Compressor Energy (Head Pressure Reset):** Efficient heat transfer from the hot refrigerant gas to the outside air at the condenser is attained by maintaining a proper temperature differential between the two. The temperature differential can be maintained using controls that reduce the condensing temperature by resetting the head pressure as the outside temperature decreases. Generally, a minimum temperature that must be maintained to ensure adequate operation of the refrigeration system is specified by the equipment manufacturer. Continuously floating condensing temperature and its associated head pressure increases the refrigeration system's capacity by over 10% and reduces compressor energy consumption by 25%.
- **Optimize Circulating Pumps Operation:** In most ice rink facilities, there are pumps that circulate a secondary refrigerant though pipes that are enclosed in the concrete slab. The pumps are a part of the refrigeration system's energy consumption directly because of their operation and indirectly because of their contribution of heat to the system. Modifications can be made to the operation of the secondary refrigerant pump to be cycled and directly controlled by ice temperature by installing infrared sensors rather than secondary refrigerant temperature sensors. The refrigeration system and the secondary refrigerant pump turn on only when the ice temperature rises above a set point. This results in a reduction of the secondary refrigerant pump's operation from 24 hours to 10 to 12 hours per day.
- **Power Factor Correction:** It is recommended to conduct a cost benefit analysis if a facility's metered power factors are lower than 90% to determine what equipment and operational changes must be implanted to increase the power factor to a percentage that prevents charges. This will result in a reduction in the overall electric demand costs, a reduction in the heat losses within the motor windings of the equipment, and minor improvement in the facility equipment's life expectancy since there are lowered heat losses in the machinery.

Lighting

The lighting system of an ice rink facility has both a direct and indirect impact on its energy consumption. Lighting also contributes to the heat load of the ice surface, which further increases the energy demand of the refrigeration system. The following energy efficient lighting system tips are suggested to reduce these costs:

- **Install More Efficient and Flexible Lighting Fixtures:**
  - LED lights contribute significantly less heat load than other types of lighting technology including fluorescent
  - Install lighting to match the ongoing activity on the ice while maintaining acceptable lighting levels.
- **Reduce Lighting Levels:**
  - Reduce the number and output of light fixtures required to achieve necessary lighting levels. This can be accomplished by using bright light-reflecting wall paint and highly reflective low-emissivity ceiling materials.
  - Utilize daylighting where and when possible to reduce electrical lighting consumption

Table 8 provides Ice Rink Activity Light Levels as Recommended by Illuminating Engineering Society of North America (IES).

Table 8 – Ice Rink Activity Light Levels as Recommended by IES[32]

Activity	Professional Hockey	Amateur Hockey	Recreational Skating
Light Level (Lux)	1,000	500	200

The content in the Ice Rink section was adapted from Refrigeration Manual: Ice Rink Applications published by Ontario Recreation Facilities Association (ORFA), 2008.

Best Practice Set-Points

- **Matching the Ice Surface Temperature to the Activity:** Adjusting the ice surface temperature to a level appropriate to the ongoing activity will lower the energy consumption of the ice rink. Energy consumption increases by about 10,000 kWh/year for each °F in the average temperature of the ice sheet. An ice sheet maintained at 23 °F (-5°C) will require 20,000 kWh/year more energy than one maintained at 25 °F (-4°C).

Table 9 – Recommended Ice Temperatures for Different Skating Activities[32]

Activity Type	Ice Temperature °C	Ice Temperature °F
Hockey	-6 to -5	21 to 23
Figure skating	-4 to -3	25 to 27
Free skating	-3 to -2	27 to 28

[32] Refrigeration Manual: Ice Rink Applications published by Ontario Recreation Facilities Association (ORFA), 2008.

Activity Type	Ice Temperature °C	Ice Temperature °F
No activity	-2 to -1	28 to 30

❖ **Lower Air Temperature at Night:** At night, approximately 50% to 60% of the load on the refrigeration system is convective load. This is caused by the movement of warm, moist air through and around the arena. Lowering the thermostat as per the below Table 10 will reduce the refrigeration system's energy consumption by an average of 3000 kWh each month. This saving is in addition to the direct savings on heating costs[32]. During colder months, the facility is recommended to maintain temperature levels high enough to prevent equipment damage or frozen pipes. Additionally, 25% to 35% of the refrigeration load at night is radiative heat from the ceiling. A well-insulated ceiling heated by building heating system will radiate heat to the ice surface. Lowering the air temperature lowers this radiative heat load.

Table 10 – Recommended Air Temperature Setpoints in Ice Rinks

Occupancy	Temperature (°C)	Temperature (°F)
Occupied	10	50
Unoccupied	-1.1 to 4.5	30 to 40

The content in the Ice Rink section was adapted from Refrigeration Manual: Ice Rink Applications published by Ontario Recreation Facilities Association (ORFA), 2008.

3.1.3. Gymnasium and Fitness Centres

Gymnasiums and fitness centres are energy intensive spaces due to the high level of plug loads and HVAC requirements. The activities conducted in these spaces lead to increased metabolic rate by as much as 5 to 7.6 times compared to sitting[33]. Higher rate of activity leads to users desiring a cooler space, which leads to a higher space cooling load and can lead to reduced space heating if equipment operates properly.

Best Operational Practices

The following is a list of major measures to consider to reduce the energy consumption in gymnasium and fitness centres:

❖ **Optimize Control Sequences:**

- Control sequences for building automation systems are often programmed during a facility's construction phase and not revisited until issues are present. However, there is a need for optimization as best practice control sequences do change over time. It is recommended that operations teams work with Energy Management to investigate if updating sequences is worthwhile for your facility.

  For Gymnasiums the main high performance sequence of operations that is recommended is Demand Control Ventilation.

[33] ASHRAE Standard 55-2017

- **Demand Control Ventilation:** The minimum airflow in a space is reset based on demand for outdoor air in the space (this requires a return air CO_2 sensor). This is a useful strategy in gymnasiums as the occupancy can vary greatly based on the activity.

❖ **Minimize Plug Loads:**

- Check that all equipment has been turned off as part of closing procedures to avoid unnecessary electrical consumption overnight
- Turn off televisions when not needed
- Consider selecting gym equipment that is ENERGY STAR® rated or self-powered

❖ **Reduce Water Usage:**

- Use low flow aerators and shower heads in the change rooms
- Ensure taps and other plumbing fixtures are not leaking

❖ **Conduct Regular Inspections:**

- Keep equipment well maintained and clean to maximize equipment efficiency and produce less heat
- Ensure thermal imaging is completed on regular basis to identify air leakage, thermal bridges, and other building envelope anomalies
- Conduct regular inspection of outdoor air dampers for Air Handling Unit / Roof Top Units to ensure that damper position is consistent with control sequences

❖ **Check High Volume/Low Speed (HVLS) Fan Operations:**

- Ensure that HVLS fans are maintained and operated appropriately based on the time of year. In winter season fans are intended to be operated at low speed to destratify air. In summer season the fans can be run at high speed to cool occupants.
- Destratifying air helps to ensure thermal comfort in the occupant range.

Best Practice Set-Points

The recommended space temperature settings for Gymnasiums are:

Table 11 - Best Practice Space Temperature Settings for Gymnasiums

Season	Occupancy	Temperature (°C)	Temperature (°F)
Summer	Occupied	23.3-25.8	74-78.5[34]
	Unoccupied	28	82
Winter	Occupied	20.3	68.5 - 74[34]
	Unoccupied	16	61

According to NRCan, adjusting the temperature down 1°C (1.8°F) in the winter can save up to 3% of the heating bill. Also, by adjusting the temperature up 1°C (1.8°F) in the summer, one can save up to 1% of the cooling bill[35].

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[34] ASHRAE Handbook 2019 HVAC Applications – Chapter 8 – Educational Facilities
[35] Dollars to $ense Energy Management Training Workshop-1 (2010). Natural Resources Canada.

The recommended humidity settings for Gymnasiums are[34]:

Table 12 – Best Practice Humidity Settings for Gymnasiums

Type	% Relative Humidity
Gymnasium without Wood Floor	30 to 60
Gymnasium with Wood Floor	35 to 50*

*For Gyms with Wood Floor 35-50% RH is suggested to be at ALL times

3.1.4. Administrative Spaces, Community Rooms, and Common Areas

Refer to Section 3.3.1 for operational considerations of office area spaces.

3.2 Transit Facilities

Transit facilities have high energy intensities due to 24/7 operating hours in many spaces with bus storage and maintenance spaces needing to re-condition air escaping from large bay doors. These facilities are comprised of a large gross floor area and made up of several space types. There is a lot of potential for energy savings due to the large amount of equipment and high ventilation requirements.

The majority of the space is taken up by two (2) classifications, storage garages and maintenance garages. Other spaces within transit facilities include office and administrative areas including kitchens, lounge for drivers, etc. The following sub-sections provide a breakdown of best operational practices and setpoints for these classifications.

3.2.1. Storage Garage and Maintenance Garages

Transit storage and maintenance garages use similar strategies for conditioning air in the space. The key difference between these two spaces is not they type of HVAC and control systems that are installed but how they operated. Storage garages are required to maintain buses at an adequate temperature to ensure winter start-up and shelter for the buses during unused hours. Since maintenance garages are occupied spaces for maintenance they have more stringent requirements in terms of temperature setpoint and air circulation which can lead to higher energy demand.

Best Operational Practices

Behaviour

This sub-section includes tips to change staff behaviour for to minimize energy use during operations.

❖ **Training:**

- Educate City staff and building occupants about behaviour change and its effect on energy use.
- Ensure that team members from every department are informed of the importance of energy management and basic energy-saving practices by holding regular staff meetings on energy use, costs, objectives, and employee responsibilities. These staff meetings can result in energy savings which can in turn save money for the City and assist in meeting our energy related corporate performance targets.

❖ **Getting Involved:**

- Encourage employees to participate in energy reduction and energy-related behaviour change by rewarding energy-efficient behaviours and habits.

Operations and Maintenance

This sub-section includes tips for Operations and Maintenance low cost and no cost measures that can be implemented to optimize operations and save energy.

❖ **Perform Regular Audits:**

- Conduct a nighttime audit to determine unnecessary after hours usage.
- Ensure thermal imaging is completed on annual basis to identify air leakage, thermal bridges, and other building envelope anomalies that contribute to poor energy performance.
- Work with the Energy Management team to have energy audits completed to identify areas for energy conservation and optimized efficiency performance.

❖ **Perform Building Commissioning:**

- Establish an existing building commissioning process at regular intervals to ensure current facility requirements are being met and systems are optimized to meet these current requirements

❖ **Perform Regular Preventative Maintenance:**

- Check heating and cooling equipment to ensure efficient operation. This can be done through scheduled preventive maintenance program completed by contractor.
- Regularly change or clean HVAC filters every month during peak points of cooling or heating season. Dirty filters have a higher pressure differential causing fans to work harder, clean filters will not overwork the equipment and will improve indoor air quality.

❖ **Complete Regular Inspections:**

- Visually inspect for insulation damage, such as tears, compression, and stains on all piping, ducting, and equipment.
- Ensure weather stripping is in good condition and is acting as an air barrier between thermal zones. Weather stripping can be added to doors and windows to reduce the loss of conditioned air saving money and energy.

❖ **Optimize Water Usage**:

- Use low flow aerators and ensure that taps and other plumbing fixtures are not leaking.
- Install low flow plumbing fixtures (urinal, water closet, shower head, etc.)

HVAC

This section provides insight into optimal operations for HVAC equipment including no and low cost tips and tricks.

❖ **Optimize Control Sequences[36]:**

- Control sequences for building automation systems are often programmed during a facility's construction phase and not revisited until issues are present. However, there is a need for optimization as best practice control sequences do change over time. In 2018, ASHRAE published *ASHRAE Guideline 36 – High Performance Sequences of Operations for HVAC*

[36] ASHRAE Guideline 36 - 2018

Systems. This guideline includes the latest best practice sequence of operations for air side HVAC equipment. It is recommended that operations teams work with Energy Management to investigate if updating sequences is worthwhile for your facility.

Before updating sequences, the following questions can be asked to determine if the HVAC system is designed for part loading:

- Is air handling equipment currently equipped with variable speed fans?
- Does the area in consideration have variable air volume boxes?

- Strategies that would be considered for control sequence optimization include:
  - **Dual Maximum VAV Logic:** This strategy places a maximum temperature on discharge air temperature in reheat applications and allows airflow to increase (instead of discharge air temperature) if the setpoint is not met. This reduces stratification and the energy necessary for reheat.
  - **Dynamic Demand Control Ventilation:** The minimum airflow in a space is reset by zone based on demand for outdoor air in that zone (this requires zone CO_2 sensors)
  - **Trim and Response Logic for Static Pressure Reset:** Zones issue airflow "requests" based on VAV damper position. For example, a 100% open damper position would send a request to the air handling unit that would in turn increase the static pressure setpoint to provide more air to the requesting zone. This works to decrease the setpoint as well when a damper is at minimum position.
  - **Trim and Response Logic for Discharge Air Temperature Reset:** Zones issue temperature "requests" based on heating or cooling demand. For example, an unsatisfied heating setpoint would generate a request to the air handling unit that would in turn increase the heating valve position to provide more heating to the requesting zone.

❖ **Control System Maintenance:**

- Review occupied and unoccupied setpoint temperatures and ensure that temperature setbacks are functional.
- Review and make any necessary adjustments to temperatures for seasonal changes, this includes removing any overrides.
- Ensure maintenance contractors calibrate sensors and thermostats to provide accurate ambient temperature readings.
- Conduct regular inspection of outdoor air dampers for Air Handling Unit / Roof Top Units to ensure that damper position is consistent with control sequences.

❖ **Control Solar Heat Gain:**

- Control direct sunlight through windows using the shades and blinds control heat gain depending on the season and local climate. See the lighting section for tips on use of windows to lower lighting loads.
- Install window films and add insulation or reflective roof coating to reduce energy consumption.

- **Complete Regular Preventative Maintenance:**
  - Clean the evaporator and condenser coils on heat pumps, or air-conditioners. Dirt on heating and cooling coils can have a significant impact on building energy use. Dirty coils reduce airflow, decrease heat exchanger efficiency, and reduce HVAC system capacity
  - Repair leaks and adjust pressure in compressed air systems.
  - High speed roll up doors between thermal zones are recommended to be properly maintained. These thermal zones include interior to exterior as well as between storage and maintenance garages.
  - Ensure air curtains are functioning properly on overhead doors between spaces with different thermal zones.
  - Service heating, ventilation, and air conditioning (HVAC) systems with a regular maintenance contract.
- **Check High Volume Low Speed (HVLS) Fan Operations:**
  - Ensure that HVLS fans are maintained and operated appropriately based on the time of year. In winter season fans are intended to be operated at low speed to destratify air. In summer season the fans can be run at high speed at cool occupants.
  - Destratifying air helps to ensure thermal comfort in the occupant range.
- **Conduct Regular Reviews of Systems:**
  - Ensure that areas in front of vents are clear of obstructions
  - Plug air leaks with weather stripping and caulking.
  - Keep exterior doors closed when HVAC equipment is in operation.
  - Repair damaged insulation and replace missing insulation.

Plug Loads

This sub-section includes information for minimize existing plug and process loads as well as information on selecting new equipment when necessary.

- **Minimize Existing Plug Loads:**
  - Enable the power management function on office computers, printers, copiers, fax machines, scanners, and multifunction devices to automatically put equipment to sleep mode when not in use[37]
  - Plug electronics into a "smart" power strip that allow for power designation for electronics depending on their usage priority.
- **Selecting New Equipment:**
  - Purchase energy-efficient products such as ENERGY STAR® certified office equipment, electronics, and commercial cooking equipment.

[37] Put Your Computers to Sleep (www.energystar.gov/powermanagement Accessed April 2020)

Lighting

This sub-section provides information to optimize lighting systems. This includes strategies to maximize efficiency and to reduce on time.

❖ **Reduce Unnecessary On Time:**

- Turn off lights when not in use or take advantage of sufficient natural daylight to reduce lighting costs by 10% to 40%.
- Install occupancy sensors to reduce lighting usage in storage rooms, meeting rooms, and other low-traffic areas.
- Use daylight in place of lights whenever possible this can be done manually with blind or can be automated with photocells.

❖ **Optimize Existing Lighting:**

- Use task lighting where feasible instead of overhead lighting for better lighting and reduced energy consumption
- Remove unnecessary lamps in over lit areas. Check your light levels against standards from the Illuminating Engineering Society (IES) to determine appropriate lighting levels for each room.

❖ **Upgrade Old Technology:**

- Replace fluorescent and incandescent lighting with energy-efficient lighting systems that improve light quality, reduce heat gain, and increase intervals between replacements.
- Install LED exit signs to reduce maintenance, replacement, and annual electricity costs.
- Install LED bulbs wherever possible
- Consider switching from high-pressure sodium lamps or metal halide lamps to LED in parking lots and for outdoor signage.

The content in this section was adapted from ENERGY STAR®[38]

Best Practice Set-Points

The recommended space temperature settings for Storage and Maintenance Garages are:

Table 13 – Best Practice Space Temperature Settings for Storage & Maintenance Garages

Space Type	Season	Temperature (°C)	Temperature (°F)
Storage	Summer	24	75
	Winter	16	61
Maintenance	Summer	24	75
	Winter	20	68

[38] Take a comprehensive approach (https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/comprehensive-approach Accessed April 2020)

According to NRCan, adjusting the temperature down 1°C (1.8°F) in the winter can save up to 3% of the heating bill. Also, by adjusting the temperature up 1°C (1.8°F) in the summer, one can save up to 1% of the cooling bill[39].

3.2.2. Office Areas

Refer to Section 3.3.1 for operational considerations of office area spaces.

3.3 Corporate Office Facilities

Corporate office facilities that are owned and managed by the City are less energy intensive than the City's largest consumers within the community centre and transit archetypes. However, corporate office facilities still present a number of opportunities to save energy through operational changes, behaviour, and technology improvements within the various space types that can be found in these facilities.

The following sub-sections provide best practice recommendations for areas within corporate office facilities that have distinct energy needs, including: office areas, kitchen areas, and data centres.

3.3.1. Office & Administrative Areas

Office and administration spaces are common to both dedicated corporate office facilities and the other facility archetypes noted within this document. Office areas include open office areas, enclosed offices and meeting rooms. In office spaces, energy usage is largely comprised of space heating and cooling needs, lighting, computers and office equipment, and other miscellaneous plug loads. The energy efficient operation of office spaces not only saves on energy costs, but also improves working conditions which is shown to improve employee health and productivity[23].

Best Operational Practices

Behaviour

This sub-section includes tips to change staff behaviour for high performance operations.

❖ **Training:**

- Educate City staff and building occupants about behaviour change and its effect on energy use.
- Ensure that team members from every department are informed of the importance of energy management and basic energy-saving practices by holding regular staff meetings on energy use, costs, objectives, and employee responsibilities. These staff meetings can result in energy savings which can in turn save money for the City and assist in meeting our energy related corporate performance targets.

❖ **Getting Involved:**

- Encourage employees to participate in energy reduction and energy-related behaviour change by rewarding energy-efficient behaviours and habits.

Operations and Maintenance

This section includes tips for Operations and Maintenance low cost and no cost measures that can be implemented to optimize operations and save energy.

❖ **Perform Regular Audits:**

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[39] Dollars to $ense Energy Management Training Workshop-1 (2010). Natural Resources Canada.

- Conduct a nighttime audit to determine unnecessary after hours usage.
- Perform energy audits to identify areas for energy conservation and optimized efficiency performance.
- Ensure thermal imaging is completed on annual basis to identify air leakage, thermal bridges, and other building envelope anomalies that contribute to poor energy performance.
- Re-commission the building to ensure original purpose for operations is being sustained.
- Work with the Energy Management team to have energy audits completed to identify areas for energy conservation and optimized efficiency performance.

❖ **Perform Regular Preventative Maintenance:**

- Improve operations and maintenance practices by maintaining equipment and ensuring efficient functionality on a regular basis.
- Regularly perform maintenance of heating and cooling equipment to ensure efficient operation.
- Optimize start-up time, power-down time, and sequencing to applicable equipment.

❖ **Optimize Water Usage:**

- Repair leaking faucets and equipment.

❖ **Complete Regular Inspections:**

- Visually inspect insulation for insulation damage, such as tears, compression, and stains, on all piping, ducting and equipment.
- Make sure weather stripping is in good condition and is acting as an air barrier between thermal zones. Weather stripping can be added to doors and windows to reduce the loss of conditioned air saving money and energy.

❖ **Other:**

- Revise janitorial practices to reduce number of usage hours for lighting.

HVAC

This section provides insight into optimal operations for HVAC equipment including no cost and low cost tips and tricks.

❖ **Optimize Control Sequences[40]:**

- Control sequences for building automation systems are often programmed during a facility's construction phase and not revisited until issues are present. However, there is a need for optimization as best practice control sequences do change over time. In 2018, ASHRAE published *ASHRAE Guideline 36 – High Performance Sequences of Operations for HVAC Systems*. This guideline includes the latest best practice sequence of operations for air side HVAC equipment. It is recommended that operations teams work with Energy Management to investigate if updating sequences is worthwhile for your facility.

[40] ASHRAE Guideline 36 - 2018

Before updating sequences, the following questions can be asked to determine if the HVAC system is designed for part loading:

- o Is air handling equipment currently equipped with variable speed fans?
- o Does the area in consideration have variable air volume boxes?

- Strategies that would be considered include:

  - **Dual Maximum VAV Logic:** This strategy places a maximum temperature on discharge air temperature in reheat applications and allows airflow to increase (instead of discharge air temperature) if the setpoint is not met. This reduces stratification and the energy necessary for reheat.
  - **Dynamic Demand Control Ventilation:** The minimum airflow in a space is reset by zone based on demand for outdoor air in that zone (this requires zone CO_2 sensors)
  - **Trim and Response Logic for Static Pressure Reset:** Zones issue airflow "requests" based on VAV damper position. For example, a 100% open damper position would send a request to the air handling unit that would in turn increase the static pressure setpoint to provide more air to the requesting zone. This works to decrease the setpoint as well when a damper is at minimum position.
  - **Trim and Response Logic for Discharge Air Temperature Reset:** Zones issue temperature "requests" based on heating or cooling demand. For example, an unsatisfied heating setpoint would generate a request to the air handling unit that would in turn increase the heating valve position to provide more heating to the requesting zone.

❖ **Control System Maintenance:**

- Review occupied and unoccupied setpoint temperatures and ensure that temperature setbacks are functional.
- Review and make any necessary adjustments to temperatures for seasonal changes, this includes removing any overrides.
- Ensure maintenance contractors calibrate sensors and thermostats to provide accurate ambient temperature readings.
- Conduct regular inspection of outdoor air dampers for Air Handling Unit / Roof Top Units to ensure that damper position is consistent with control sequences.
- Calibrate thermostats to provide accurate ambient temperature readings.

❖ **Control Heat Gain:**

- Control direct sun through windows using the shades and blinds to prevent or encourage heat gain depending on the season and local climate. See the lighting section for tips on use of windows to lower lighting loads.
- Install window films and add insulation or reflective roof coating to reduce energy consumption.

❖ **Complete Regular Preventative Maintenance:**

- Regularly change or clean HVAC filters every month during peak points of cooling or heating season. Dirty filters have a higher pressure differential causing fans to work harder, clean filters will not overwork the equipment and will improve indoor air quality.
- Service heating, ventilation, and air conditioning (HVAC) system with a regular maintenance contract.
- Clean the evaporator and condenser coils on heat pumps, chillers, or air-conditioners. Dirt on heating and cooling coils can have a significant impact on building energy use. Dirty coils reduce airflow, decrease heat exchanger efficiency, and reduce HVAC system capacity
- Repair leaks and adjust pressure as required in compressed air systems.

❖ **Conduct Regular Review of Systems:**

- Ensure that areas in front of vents are clear of obstructions
- Plug air leaks with weather stripping and caulking.
- Keep exterior doors closed when HVAC equipment is in operation.
- Repair damaged insulation and replace missing insulation.

Plug Loads

This sub-section includes information for optimizing existing plug and process loads as well as information on selecting new equipment when necessary.

❖ **Minimize Existing Plug Loads:**

- Enable the power management function on office computers, printers, copiers, fax machines, scanners, and multifunction devices to automatically put equipment to sleep mode when not in use[41]
- Plug electronics into a "smart" power strip that allow for power designation for electronics depending on their usage priority.

❖ **Selecting New Equipment:**

- When purchasing new equipment select energy-efficient products such as ENERGY STAR® certified office equipment, electronics, and commercial cooking equipment.

Lighting

This sub-section provides information to optimize lighting systems. This includes strategies to maximize energy efficiency and conserve energy with the reduction of on time.

❖ **Reduce Unnecessary On-Time:**

- Turn off lights when not in use or take advantage of sufficient natural daylight to reduce lighting costs by 10% to 40%.
- Only light occupied areas of the facility during cleaning rather than having large unoccupied areas lit after-hours

[41] Put Your Computers to Sleep (www.energystar.gov/powermanagement Accessed April 2020)

- Install occupancy sensors to reduce lighting usage in storage rooms, meeting rooms, and other low-traffic areas.
- Employ bi-level switching where applicable. Bi-level switching allows you to control a lighting system in groups of fixtures or lamps. For example, bi-level switching allows you to turn off half of the lights in a room off when full illumination is not required. This is useful in rooms like meeting rooms where the lighting levels may vary based on the meeting type and the use of presentation equipment.
- Use daylight in place of lights whenever possible this can be done manually with blind or can be automated with photocells.

❖ **Optimize Existing Lighting:**

- Use task lighting where feasible, such as periods of reduced occupancy where overhead lighting can be turned off.
- Ensure all light fixtures lenses are well maintained and clean to ensure lighting levels are adequate
- Check your light levels against standards from the Illuminating Engineering Society (IES) to determine appropriate lighting levels for each room. Remove unnecessary lamps in over lit areas.
- Ensure proper performance of occupancy sensors. Ensure sensors turn on lights when the room is occupied. If there are issues it may be due to the positioning of the occupancy sensor or the sensor settings.
- Ensure that exterior lights are turned off during daylight hours. Use an astronomical timer. It can be set to adjust itself for daylight savings.

❖ **Upgrade Old Technology:**

- Replace old fluorescent and incandescent lighting with energy-efficient lighting systems that improve light quality, reduce heat gain, and increase intervals between replacements.
- Install LED exit signs to reduce maintenance, replacement, and annual electricity costs.
- Install energy efficient light bulbs in desk and floor lamps.
- Consider switching from high-pressure sodium lamps or metal halide lamps to LED in parking lots and for outdoor signage.

The content in this section was adapted from ENERGY STAR®[42].

Best Practice Set-Points

The recommended temperature settings for office areas are:

[42] Take a comprehensive approach (https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/comprehensive-approach Accessed April 2020)

Table 14 - Best Practice Space Temperature Settings for Offices

Season	Occupancy	Temperature (°C)	Temperature (°F)
Summer	Occupied	23.3-25.6	74-78[43]
	Unoccupied	28	82
Winter	Occupied	21.1-23.3	70-74[43]
	Unoccupied	16	61

According to NRCan, adjusting the temperature down 1°C (1.8°F) in the winter can save up to 3% of the heating bill. Also, by adjusting the temperature up 1°C (1.8°F) in the summer, one can save up to 1% of the cooling bill[44].

The recommended humidity settings for office areas are:

Table 15 – Best Practice Space Humidity Settings for Office[43]

Season	Humidity (%)
Summer	50 to 60
Winter	20 to 30

Low levels of humidity, which mainly occur during the winter can increase the number of paper jams and static electricity. High levels of humidly during the summer increases, the "feels like" temperature and the chance of mould growth within the office environment. In areas with high levels of glazing, humidity levels that are too high in the winter may cause condensation. If this occurs, consider resetting the humidity setpoint based on outdoor air temperature and humidity using a reset schedule. Contact Energy Management for more information.

3.3.2. Kitchen Areas

Kitchen areas have high exhaust rates and large amount of heat load from cooking equipment. Due to the high energy intensive nature of this area, it is very important to provide adequate conditioned make-up air. It is recommended to perform regular maintenance on all kitchen systems including all exhaust and supply air units.

Best Operational Practices

Behaviour

This sub-section includes tips to change staff behaviour for high performance operations.

❖ **Training:**

- Educate City staff and building occupants about behaviour change and its effect on energy use.
- Ensure that team members from every department are informed of the importance of energy management and basic energy-saving practices by holding regular staff meetings on energy use, costs, objectives, and employee responsibilities. These staff meetings can result in energy savings which can in turn save money for the City and assist in meeting our energy related corporate performance targets.

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[43] ASHRAE Handbook 2019 HVAC Applications – Chapter 3 – Commercial and Public Buildings
[44] Dollars to $ense Energy Management Training Workshop-1 (2010). Natural Resources Canada.

❖ **Getting Involved:**

- Encourage employees to participate in energy reduction and energy-related behaviour change by rewarding energy-efficient behaviours and habits.
- Use cold water in place of hot water wherever possible

Operations and Maintenance

This sub-section includes tips for Operations and Maintenance low cost and no cost measures that can be implemented to optimize operations and save energy.

❖ **Reduce Water Usage:**

- Ensure that low flow faucet aerators are installed to reduce hot water usage
- Encourage the reporting of any water leaks and fix identified leaks as even small leaks may add up to increased energy costs for hot water

❖ **Complete Regular Equipment Maintenance:**

- For existing refrigerators, clean refrigerator coils twice a year and replace door gaskets if a dollar bill easily slips out when closed between the door's seals.

HVAC

This sub-section provides insight into optimal operations for HVAC equipment including no cost and low cost tips and tricks.

❖ **Optimize Equipment Operation Time:**

- Ensure cooking exhaust systems are used only when necessary

❖ **Ensure Equipment Is Operating Efficiently:**

- Maximize the exhaust hood overhang by pushing cooking appliances as close to the wall as possible.[45] This ensures that exhaust air is directed properly and clean air is not exhausted.
- Clean oven surfaces to ensure proper heat transfer
- Ensure air distribution areas such as louvers, grilles, etc. are left unobstructed.

❖ **Complete Regular Preventative Maintenance:**

- Ensure HVAC equipment is maintained by HVAC contractor

Plug Loads[46]

This sub-section includes information for optimizing existing plug and process loads as well as information on selecting new equipment when necessary.

❖ **Ensure Optimal Setpoints are Used:**

- Adjust the refrigerator thermostat. If your thermostat is set for colder than it needs to be, your fridge may be consuming up to 25% more energy than necessary. For best results, the

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[45] ENERGY STAR ® Guide for Commercial Kitchens (https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/energystar/Commercial-Kitchen-Guide_E_acc.pdf Accessed April 2020)

[46]Energy Savings Tips for Small Businesses (https://www.energystar.gov/sites/default/files/tools/Small_Business_Offices_0.pdf Accessed April 2020)

refrigerator is recommended to be set within the 2.5 – 4.5 degrees C range, and the freezer to between -18 to -15 degrees C.

❖ **Ensure Equipment is Properly Functioning:**

- Use dishwashers only when full to conserve energy, water, and detergent as most dishwashers use the same amount of water and energy whether they're run full or half-full.
- Maintain an air-gap of at least three inches between the back of refrigerators, water coolers, and freezers and the wall

❖ **Schedule Equipment:**

- Use timers to ensure that coffee maker heating elements are not operating during off hours.

❖ **Replace Old Equipment:**

- Consider retrofitting existing refrigerators and display cases with anti-sweat door heater controls, and variable speed evaporator fan motors and controls.
- When purchasing new equipment select energy-efficient products such as ENERGY STAR® certified office equipment, electronics, and commercial cooking equipment.

Lighting

This sub-section provides information to optimize lighting systems. This includes strategies to maximize efficiency and to reduce on time.

❖ **Reduce Unnecessary On Time:**

- Turn off lights manually in seldom-used rooms and/or install motion detector switches to ensure electricity is not used to light unoccupied spaces such as closets, storage or break rooms, restrooms and even walk-in refrigerators. For refrigerators, look for low-temperature-specific, sealed sensors. [47]

❖ **Optimize Existing Lighting:**

- Inspect lenses and reflectors for dust, rust or damage that could cause inefficient transmission or reflection of light. [47]

❖ **Replace Old Technology:**

- Ensure LED bulbs and fixtures are installed wherever feasible

Best Practice Set-Points

The recommended temperature settings for kitchen areas are:

[47] ENERGY STAR ® Guide for Commercial Kitchens (https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/energystar/Commercial-Kitchen-Guide_E_acc.pdf Accessed April 2020)

Table 16 – Best Practice Space Temperature Settings for Kitchen Areas[48]

Season	Occupancy	Temperature (°C)	Temperature (°F)
Summer	Occupied	28.9-31.1	84-88
Winter	Occupied	21.1-23.3	70-73.5

No humidity control is provided in kitchen areas.[49]

According to NRCan, adjusting the temperature down 1°C (1.8°F) in the winter can save up to 3% of the heating bill. Also, by adjusting the temperature up 1°C (1.8°F) in the summer, one can save up to 1% of the cooling bill[50].

3.3.3. Data Centres

WIP

3.4 Library

WIP

3.5 Fire Stations

WIP

[48] ASHRAE Handbook 2019 HVAC Applications – Chapter 3 – Commercial and Public Buildings
[49] ASHRAE Handbook 2019 HVAC Applications – Chapter 3 – Commercial and Public Buildings
[50] Dollars to $ense Energy Management Training Workshop-1 (2010). Natural Resources Canada.

APPENDIX – BAS DESIGN AND IMPLEMENTATION PRINCIPLES

The BAS Guideline Methodology provides a high level description of the purpose and structure of the BAS Guidelines. This section includes the City of Brampton BAS design and implementation principles, overviews of the different sections within the BAS Guidelines as well as the intended audience for the different sections.

Chapter 1. Principles of BAS Design and Implementation

1.1 Integrated Design Vision

A Building Automation System is a series of networked controllers and a software headend designed to monitor and control the environment in a building. It controls all aspects of the HVAC and can extend to include lighting, sub-metering, security and more. It ensures the operational performance of the building systems as well as ensuring the comfort and safety of the building's occupants. The City of Brampton intends for its building automation systems to be an integral part of Energy Management by reducing energy consumption and GHG emissions.

Additionally, it is the goal of the city to shift design, construction and commissioning processes from a linear, individualized approach to an integrated and collaborated approach. It is the intention of this guideline that all aspects of the BAS design and implementation is considered holistically and applied through an iterative process. This involves looking at the interoperation of disparate systems and considering how these systems are to work together.

1.2 Guideline Goals

As a Green City, Brampton has committed to zero carbon and high performance facilities. This commitment for A Zero Carbon Transition has been formalized through the City of Brampton's latest 5-year Energy and Emissions Management Plan for 2019-2024. The plan outlines the action plan to achieve a zero carbon transition for the City's new and existing corporate facilities. In accordance with the Paris Agreement, Brampton has adopted the provincial and federal greenhouse gas (GHG) emission reduction targets of 30% by 2030 and 80% by 2050, respectively, using a 2010 baseline. The federal target has since been updated to net-zero emissions by 2050 (re-affirmed by the Minister of Environment and Climate Change at the 2019 UN Climate Change Conference)[51]. The

City has set an interim target of 20% GHG emissions reduction by 2024.

The design and implementation of Building Automation Systems is intended to support the three objectives of the Zero Carbon Transition Plan:

1. Minimize energy use
2. Minimize emissions
3. Maximize cost recovery

1.1 Six Principles of BAS Design

1. **Reliable control** of systems which also includes alarms and trend logs must be provided in a BAS
   The ultimate quality of a control system is primarily dictated by the components that sense, execute logic for, actuate and document the systems they are controlling[52]
2. **Require sufficient instrumentation** the designer is responsible for ensuring specified equipment will meet sequences.
   The designer must require instrumentation to support both the sequence of operations, and the data acquisition capability to support equipment performance monitoring and building diagnostics

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52 https://getrede.ca/five-principles-for-building-automation-systems/

analysis. A listing generally establishing minimum instrumentation requirements is included with the specifications. This identifies minimum instrumentation for common types of system. The designer is responsible for requiring additional instrumentation as necessary to support the sequence of operations and necessary data acquisition capabilities.

3. **Environmental control** for indoor conditions and some examples include: temperature, humidity and air quality
   The measure of an environmental control system and how well it functions with other building wide systems is determined by occupant comfort, satisfaction, and well-being.
4. **Building wide and energy efficient control** of systems and examples include: HVAC, envelope and lighting
   A key measure of the system's energy management capabilities is its ability to communicate and exchange data with other building systems to achieve efficient and effective energy usage with consideration for GHG emissions and energy cost
5. **Accessible control** which can be easily accessed and understood by operators
   Ensuring ease of operations increases the usability of the BAS which leads to better operational performance. This also includes graphics that increase Energy Awareness through better designed and easier to understand graphics and public facing portals.
6. **Integration capable control** that can incorporate disparate systems together to operate as a whole
   Examples of these disparate systems include but are not limited to BAS, metering, and security. This type of control usually hosted on a software platform that can combine disparate systems

1.2 Two Implementation Principles

1. **Highly qualified** manufacturers and installers with extensive experience are expected to complete all BAS work.
   Qualifications should ensure that a quality contractor with an extensive proven track record is specified; and that effective, thorough commissioning of the control systems by that contractor is essential. Given this, there lies a challenge to the designer to fairly restrict installers to those that can deliver effectively within the context of both the construction and the service/support arenas.

2. **Fully documented** control installation is expected with nothing required to fully operate and maintain the system withheld.
   Point naming conventions, programming logic, network configuration requirements, security information, etc. must be strictly adhered to and totally documented. No element for the continued operation and maintenance of the control system may be withheld in any way. No part of the installation may be considered confidential or proprietary information.[2]

1.3 Guideline Layout

The intended audience includes the project team and for a new building, the readers would primarily be system designers, contractors and members of the operations teams. Although, system designers do not usually include architects and may not include all members of the design development team, Energy Management recommends that the architect or design lead review the Energy Management Guidelines and the BAS chapter in order to engage appropriate resources at critical junctures of the integrated design process. For a major renovation project, the intended audience may vary slightly depending on project details, however, the same BAS design principles apply and thus, engagement of team staff would follow these principles.

The guideline identifies Implementation Guidelines (Appendix 1.0), Product Requirements (Appendix 1.1) and Execution Guidelines (Appendix 1.2) that CoB wants implemented throughout a BAS projects. It is the intention that users of this guideline will incorporate its aspects of procedure, construction, and building operation into the applicable design process.

The guideline is separated into 3 sections; Design and Implementation, Product, and Execution. A brief description of each of these sections follows to direct readers to their primary work scope.

1.4 Design and Implementation Guidelines (Designer, Installer, Operator):

This section covers information that is pertinent to many stakeholders throughout the design process, such as:

1. Expectations of preventative and demand maintenance contractors,
2. Requirements for IT networking
3. Trend log requirements

Construction handover processes

This section also includes discussions around the BAS architecture, including use of IP, MSTP, POE networks, the integration into other control systems such as a CMMS, itemizing of gateways with 3rd party devices and any software requirements should be considered.

Finally, items such as permits and fees and close out procedures are to be discussed at the beginning of the design rather than the end.

1.5 Product (Designer, Installer):

In this section, the CoB's functional requirements of equipment are outlined. In short, the BAS shall be based on ASHRAE BACnet technology (ASHRAE Standard 135-2016) and to be capable of remote communication over the City's intra-net network. CoB has provided a detailed section on the feel and flow of the graphics of the BAS with the intention of having some specific information always available. The network requirements, sensors and wiring guidelines are also defined here.

1.6 Execution (Designer, Installer, Operator):

This section is geared towards methods and hand-over procedures of implementation. Designers, commissioning agents, building operators to be included in the integrated design process from the very beginning. The process of this discussion is laid out in detail. A detailed section provides information towards how commissioning agents are to be engaged in CoB BAS projects. Consultants, BAS Vendors and Commissioning Agent are to work coherently. It is the intention of CoB that all parties are aware of major decisions well ahead of the execution phase. This increase in communication ensures less deficiencies during the commissioning phase.

Another important section is preventative maintenance contracts. The CoB has instituted a new process where the BAS preventive maintenance contractor will provide the list of rectified issues at the end of the site visit. If this is not approved by the corresponding building operations staff, and energy management staff, the invoicing will not be approved.

Chapter 2. Implementation Guidelines

2.1 Acceptable vendors

2.1.1. Vendor Listing

The following is a listing of approved BAS vendors for existing buildings. These vendors provide preventative and demand maintenance services for existing BAS systems at existing facilities:

1. Johnson Controls Canada LP
2. ESC Automation Inc.

3. Automated Logic Canada Ltd.

In 2020, the City of Brampton completed a prequalification process of BAS vendors to supply and install building automation systems (BAS) with native BACnet protocols. The prequalification enables pre-qualified vendors to bid on projects for a three (3) year period (currently up to December 31, 2023).

The types of projects will include: retrofitting existing buildings with new BAS, expanding BAS for existing facilities, and new BAS required for new construction facilities. Below is a list of prequalified vendors:

1. Johnson Controls Canada LP
2. ESC Automation Inc.
3. Siemens Canada

2.1.2. Design and construct Building Automation System (BAS) for building services with open protocol communications (BACnet).

2.1.3. New and existing installations use BACnet for all aspects of communication, including workstation, field panel, custom application controller and unitary controller communications and are commonly referred to as native BACnet systems.

2.2 Vendor Quality Assurance

2.2.1. BAS vendor to provide City of Brampton pricing options for 3 year maintenance and annual maintenance Installer must be within 50km of project site

2.2.2. Installer must be able to respond within 3 hours for critical failures, and within 24hrs for non-critical failures. Definition of critical and non-critical shall follow these guidelines as provided in Appendix B

2.3 Network

2.3.1. All BACnet devices (controllers, sensors, actuators, etc.) shall be integrated into one common network infrastructure utilizing a common network management tool and creating a single BACnet network database.

2.3.2. All systems should be complete with a dedicated controller and enclosure. For example, AHUs, Chiller Plant, Boiler Plant, Compartment Units will have a dedicated panel.

2.3.3. Provide a Facility Management and Control System incorporating BACnet, Direct Digital Control (DDC), equipment monitoring, and control consisting of microprocessor based plant control processors interfacing directly with sensors, actuators, and environmental delivery systems (i.e. HVAC units); electric controls and mechanical devices for all items indicated on drawings described herein including dampers, valves, panels, sensing devices; a primary communications network to allow data exchange between microprocessor based devices.

2.3.4. The system will consist of an open architecture that utilizes the latest ANSI/ASHRAE 135 BACnet protocol as the common communication protocol between all controlled and controlling devices. Where necessary or desired, BACnet packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth.

2.3.5. The entire system network shall be a WAN. All nodes shall communicate with each other utilizing the latest ANSI/ASHRAE 135. There will be no consideration given to any network which does not use BACnet as the primary communications network. Controllers shall be capable of sharing standard network variable data with other WAN-based/BACnet devices.

2.3.6. For Non-IP based field controllers, the network is to follow a 2-tier structure

2.3.7. BCs and AWS to be on Tier1. These are to be IP-Based controllers and connected directly to CoB's base network infrastructure.

2.3.8. AACs, ASCs, and other field controllers to be on Tier 2. These are non-IP controllers and to be connected through MS/TP infrastructure originating from the BCs

2.3.9. For fully IP (and/or POE) Based BAS infrastructures, all components of the infrastructure (AWS, BC, AAC, ASC, etc.) to reside on the CoB base-building network infrastructure.

2.3.10. The network infrastructure shall conform to the BACnet published guidelines for network wiring and system architecture. Wire type, distance, termination, and use of routers shall strictly conform to the BACnet wiring standards. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.

2.3.11. All system controllers shall utilize a peer-to-peer communications scheme to communicate with each other and with the PC-type (browser based) monitoring computer(s) if applicable. All controllers shall utilize BACnet's network as defined by BACnet. Controllers shall implement BACnet device profiles as appropriate. All devices shall be provided with a twisted wire plug-in configuration utility.

2.4 Integration

2.4.1. When applicable, potential integration to be thoroughly discussed with City of Brampton.

2.4.2. The system shall allow for future integration of other systems (Card Access, Lighting, Intrusion Monitoring etc.) on the network proposed in this document, and also share a common infrastructure for network communications, time scheduling, alarm handling, history logging, monitoring and system control.

2.4.3. The system installed shall seamlessly connect devices other than HVAC throughout the building regardless of subsystem type (i.e. HVAC, lighting, and security devices should easily coexist on the same network channel without the need for gateways).

2.4.4. Use of ANSI/CEA-852 layer 3/BACnet transparent routers is the only acceptable method spanning multiple channels and is the recommended method for system scalability. These components shall share common software for network communications, configuration, time scheduling, alarm handling, history logging, and custom programming. Any routers required by the system shall be supplied and commissioned as part of this guideline.

2.4.5. Vendor to integrate Asset Management and Capital Planning's CMMS platform. Primary use-case would be the BAS pushing alarms to CMMS.

2.5 Gateway

2.5.1. Gateways shall not be used unless specifically authorized in writing. Use of a gateway requires submittal of the documentation as required by the owner (Energy Management, City of Brampton) or owner's representative. It is the intent of this guideline that gateways be limited to integrating legacy systems where applicable. Acceptance of gateways is at the sole discretion of the owner.

2.5.2. If gateways are used, the following form is to be filled out by the user and submitted to the owner

System Name: For example- RTU1

Purpose of System: For example- Serves Auditorium

Protocol used by system: *For example- Modbus*

The BAS controller to which this system is connected to: *For example- BC1*

	BACnet Object name	3rd party Protocol slave address	BACnet object type	BACnet instance number	BACnet unit of measure	3rd Party protocol scale	BACnet scale mapped
Example Point1	Supply Air Flow	40001	Analog Input	1004	L/S	0 - 4800	0 - 4000
Point2							

2.5.3. Software Requirements

2.5.4. System Monitoring shall be provided through the installation of Graphical User Interface (GUI) software applications (B-AWS) that support Native BACnet database. It must be BTL listed product. The GUI shall provide complete access to any point in the system at any time. A complete and fully commissioned BACnet's network database must be delivered for use with the GUI as a specific deliverable as defined on the project schedule. This database must include ALL node definitions, all channel and subnet definitions, all router and repeater definitions, and all bindings etc.

2.5.5. The control system shall be designed such that mechanical and/or electrical equipment will be able to operate under stand-alone control. Functional methodology such as, but not limited to scheduling, trending, and alarming shall be outlined fully in your submittal documentation. Methodology must follow pertinent and applicable BACnet guidelines. Controllers that require a master computer or controller to perform basic functions are not acceptable. In the event of a network communication failure, or the loss of any other controller on the network, the control system shall continue to independently operate under control of the resident program stored in nonvolatile memory as detailed herein.

2.5.6. Historical data logging, alarm monitoring and management, and scheduling shall be accessible and managed via the GUI. The system may utilize specific controllers on the system to perform these functions or it may be performed by a host computer, or a combination of both. The final data to be stored on the server.

2.5.7. System shall utilize BACnet defined standard network and command messaging for all system data, shop drawings and approvals

2.5.8. All shop drawings provided by the vendor is to be submitted to the engineering consultant for review. Following the consultant's review, it is to be submitted to the Energy Management department at CoB for review

2.5.9. If there is no engineering consultant, vendor to submit directly to Energy Management department at CoB for review.

2.5.10. Following approval of shop drawing, vendor to provide sample graphics which are also to be approved by the consultant and/or CoB Energy Management team. Graphics to include typical AHU, VAV, and the Boiler or Chiller plant

2.6 Naming Convention

2.6.1. CoB has standardized on Project Haystack naming convention. All newly created points to follow this convention regardless of new building or retrofit. Haystack naming convention to apply to all representations of the points, whether it is the graphics, BACnet name or any other.

2.6.2. Each point is to be preceded by a 3 letter abbreviation of the building name and an underscore.

2.6.3. Vendor to provide owner with functionality to export all point list

2.7 Sequence of Operation

2.7.1. Sequences of operations designed and implemented to ASHRAE Guideline 36

2.7.2. Provide automatic control for system operation as described herein, although word "automatic" or "automatically", is not used.

2.7.3. Provide control devices, control software and control wiring as required for automatic operation of each sequence specified.

2.7.4. Manual operation is limited only where specifically described; however, provide manual override for each automatic operation.

2.7.5. Where manual start-up is called for, also provide scheduled automatic start-stop capabilities.

2.7.6. Functions called for in sequence of operations are minimum requirements and not to limit additional capabilities the DDC system can be provided with.

2.7.7. Minimum of the Basic Energy Efficient Sequences. Discuss Advanced Energy Sequences with the city during kick-off meeting.

2.7.8. Provide the following functions which are not specifically mentioned in each sequence of operation for each item of equipment:

1. Start-Stop, manual, and scheduled

2. On-Off status of each piece of equipment
3. Run-time
4. All set-points shall be adjustable
5. Feedback should be provided for all relevant outputs
6. Sequenced starting of all motors

2.8 Basic Energy Management

2.8.1. Provide Intelligent Control Devices, Programmable Controllers, and Application Specific Controllers as herein specified, as needed to perform functions indicated in the input/output summaries and sequences of operation, and/or indicated on the mechanical and electrical drawings.

2.8.2. Implement start, stop, night setback, request based logic, and demand level adjustment of setpoints

2.8.3. Incorporate sequences that utilize energy conserving sequences. This includes, but is not limited to; demand based economizer control, supply air temperature reset, duct static pressure reset, occupant based demand control, chilled plant optimization control, boiler plant optimization control, free cooling control, etc.

2.8.4. All major ventilation equipment to have a morning startup and evening shutdown sequence

2.8.5. All equipment in manual over ride to switch back to automatic control after a stipulated time interval.

2.8.6. BAS to have 3 levels of occupancy schedules: Unoccupied, Occupied and High-Occupancy. Setpoints, flowrates, timing to all be adjustable to suit the needs of the 3 states.

2.9 Demand Response

2.9.1. All components of this section is to be discussed with Energy Management team at CoB and will be potentially applicable to any building with a potential demand more than 1MW of electrical energy.

2.9.2. The BAS will be linking to the IESO (Independent Electricity System Operator) website for automatic demand reduction when prices are high. Provide a focused set of energy. Required information includes, but shall not be limited to:

- Site energy overview
- Equipment runtime
- Load profile
- Electrical energy
- Simple energy cost
- Energy production
- Consumption
- Reports shall be selectable by date, time, area and device. Each report shall include a color visual summary of essential energy information.

2.9.3. The System shall provide a Demand Limiting and Load Rolling program for the purpose of limiting peak energy usage and reducing overall energy consumption.

2.9.4. The system shall maintain consumption below the target by selectively shedding loads based upon a user defined strategy. The Load Rolling program shall sum the loads currently shed and compare it to a user defined Load Rolling Target.

2.9.5. Software shall be provided to configure and implement optimal start and stop programs based on existing indoor and outdoor environmental conditions as well as equipment operating history.

2.9.6. Use a peak demand alarm: an announcement that the peak demand is being approached will allow operators to take action to avoid consumption during peak demand.

2.10 BAS Alarm Configuration

2.10.1. Alarms to be configured on all inputs corresponding to output points which are controlled by the BAS through a setpoint or command. The reference points for the alarms to be the setpoint. By default, alarm to be raised if input feedback deviates from setpoint by 20% or feedback does not match command for more than 10 minutes continuously.

2.10.2. Vendor to provide functionality to allow owner to export all alarms in an XLS format

2.10.3. Color code the of critical and non-critical alarms to follow the guidelines

2.10.4. BAS vendor to discuss with Energy Management group for further information regarding Alarm Levels.

2.10.5. Alarms to be sent to applicable building operators. If operators do not answer alarms, escalate alarm to the next level as determined by operations teams.

2.10.6. Alarms to be written in the following format:

2.10.7. Name. For example AHU1

2.10.8. Issue: For example: System Command does not meet Status

2.10.9. Provide alarm recognition, storage, routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.

2.10.10. Shall be able to route any alarm condition to any defined User location whether connected to a local network or remote via or wide-area network.

2.10.11. Alarm generation shall be selectable for annunciation type and acknowledgement requirements.

2.10.12. Control equipment and network failures shall be treated as alarms and annunciated.

2.10.13. Alarms shall be annunciated via email notification to specific, configurable email address.

2.10.14. Alarms shall be visually identified via the HTML5 graphics pages. Overrides and set point changes shall be configured via the HTML5 interface.

2.10.15. Alarms shall be annunciated in any of the following manners as defined by the user:

1. Screen message text
2. Email or Text messages
3. Graphic with flashing alarm object(s)

2.10.16. Alarms shall be logged for a period of no less than 1 week

2.10.17. Alarm logs shall be able to be transferred from the web server to a host

2.10.18. The following shall be recorded by the Web Server for each alarm (at a minimum):

1. Time and date
2. Location (building, floor, zone, office number, etc.)
3. Equipment (air handler number, access way, etc.)

2.11 Warranty

2.11.1. All installed systems and their pertaining components, including but not limited to labour, material and configuration should have a 1 year warranty.

2.11.2. All warranty packages to be sent to City of Brampton Energy Management Team

2.12 Computerized Maintenance Management System (CMMS)

2.12.1. BAS to be integrated with the work order system. BAS vendor to reach out to Asset Management and Capital Planning's to configure integration where applicable.

2.13 Remote Access

2.13.1. The owner shall provide an appropriate connection (static IP) to the Internet to enable remote system access. The owner agrees to pay monthly access charges for connection and ISP.

2.14 BAS as a Web service

2.14.1. All BAS to be installed on City of Brampton's virtual servers

2.14.2. Servers shall be capable of executing application control programs to provide:

1. Hosting of the graphical HTML5 pages
2. Calendar functions
3. Scheduling
4. Data Logging
5. Alarm monitoring and routing
6. Time synchronization
7. Soap/XML interface
8. Static or Dynamic IP addressing
9. SMTP Server for alarm email notification
10. Messages and message management

2.14.3. The Software License for the Web Server(s) must be open and enable any Systems Integrator to engineer, change or modify the application once the project is complete. Restrictive engineering access to the Web server will not be acceptable. City of Brampton's Digital Innovation Team will review the license to ensure that all applicable procurement laws and regulations have been followed (e.g., renewal period, copyright, limited warranty, liabilities and other terms & conditions). All credentials, access rights and passwords will be provided to the City.

1. Include all applicable items for 3rd party systems as well, such as, but not limited to RTU configurations tools or other packaged controls systems.

2.14.4. The system shall be capable of supporting unlimited simultaneous client connections using a standard Web browser such as, but not limited to Microsoft Edge™, Firefox™, or Google Chrome™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture- specific browsers shall not be acceptable.

2.14.5. The Web browser shall provide a view of the system, in terms of graphics, schedules, calendars, logs, etc. Systems that require different views or that require different means of interacting with objects such as, but not limited to schedules, or logs, shall not be permitted.

2.15 Data Logging and Storage

2.15.1. Vendor to setup BAS such that it creates trendlogs of all Inputs, Outputs and Setpoints.

2.15.2. All binary trended values to be logged at each Change of Value (COV)

2.15.3. All analog trended value to follow the guidelines as provided in Appendix B

2.15.4. BAS to be setup to store trend logs for a minimum of 2 years. The first year to be held as a benchmark.

2.15.5. Trend logs interface name and BACnet name to match the BAS point name as seen on the graphics.

2.15.6. The BAS shall have the ability to collect data for any Inputs, Outputs and Setpoints and store this data in the City BAS Server for future use. Data logging shall be performed either by a dedicated logger on the control network, via a combined web server/data logger, or by a maximum of 1 central host PC attached to the network. Whichever way data logging is to be performed it must:

1. Automatically update the host storage PC that the logs are approaching their full level
2. Data logs shall be able to be transferred from the web server to a host
3. Be easily able to append a new log to a previously saved log

2.15.7. Data to be property of CoB

2.15.8. Data to be available in .CSV format at the very least for CoB to be accessed anywhere within the network

2.15.9. Data to be automatically graphed in the BAS and normalized accordingly.

2.16 Security and User Administration

2.16.1. Communications between the Web Server and Web Browser to be secured according to CoB's latest Digital Innovation Team standards. Vendor to reach out to CoB Digital Innovation Team department for more information.

2.16.2. A license allowing for unlimited amount of user accounts should be provided to the CoB.

2.16.3. All accounts to be authenticated using CoB active directory. Vendor to communicate with Energy Management department to create authentication.

2.17 Main (Virtual) Server for all BAS

2.17.1. All BAS vendors are responsible to upgrade the existing BAS server with the latest version during the execution of this contract/project.

2.17.2. A City of Brampton Virtual Server for all BAS operation is will be allocated to vendor.

1. Virtual Server is owned by the City of Brampton and will house all software pertaining to the BAS.
2. City of Brampton's Digital Innovation Team will provide access to the BAS vendor to the existing server to install, interface and configure the new/existing BAS.

2.17.3. Server supplied by vendor for BAS operations is not acceptable. BAS Vendor is responsible to interface the new/existing BAS to the available server.

2.17.4. All trends, graphs and database will be residing in the existing Virtual Server. Contact Energy Management group for details.

2.18 BAS Workstation

2.18.1. A BAS workstation is not to be provided because the City of Brampton utilizes a Virtual Server model, the BAS shall be accessed remotely from any terminal.

2.18.2. A BAS Workstation's purpose is to provide a remote terminal to access the BAS which is installed in the server.

2.19 Permits and Fees

2.19.1. It is the responsibility of the contractor to apply for, obtain and pay for all permits, licenses, inspections, certificates, examinations and fees as required.

2.19.2. Vendor to arrange for inspection of all work by the authorities having jurisdiction over the Work. The final certificate of the inspecting authorities are to be presented to the Engineer for approval.

2.19.3. Comply with the requirements of the latest edition of the applicable ULC or CSA standards, the requirements of the Authorities, Federal, Provincial/Territorial and Municipal Codes, the applicable standards of ULC and all other authorities having jurisdiction. These Codes and Regulations constitute an integral part of these Specifications.

2.19.4. In case of conflict, applicable Codes take precedence over the Contract Documents.

2.19.5. Before starting any work, submit the required number of copies of documentation to the authorities for their approval and comments. Comply with any changes requested as part of the Contract, but notify the Engineer immediately of such changes, for proper processing of these requirements. Prepare and furnish any additional drawings, details or information as may be required.

2.20 Close Out Procedures, Documentation and Submittals

2.20.1. The contractor shall provide all required hardware and software necessary to implement the functions shown or as implied in the contract documents.

2.20.2. If a dedicated configuration tool is provided, it is preferable that it be launched from within the applicable Network Management Software. If not, any software required for controller configuration shall be included as a leave-behind tool with enough license capability to support the installation and future operational troubleshooting.

2.20.3. Upon job completion, complete the following checklist to ensure all documents have been provided:

Item#	Reference	Comment
1.	Warranty Letter	☐ Received
2.	Resource files with sequences and configuration files	☐ Received
3.	Start-up Reports for Equipment	☐ Received ☐ No Deficiency
4.	Balancing Report (if applicable)	☐ Received ☐ No Deficiency
5.	O&M Manual	☐ Received Final No Comments
6.	As-Built	☐ Received Final Electrical Version

Chapter 3. Product Guidelines

3.1 General

3.1.1. This section defines the Basic Materials and Methods provided by the Controls Contractor and used in the installation of BACnet Control products to provide the functions necessary for control of the mechanical systems on this project. Please be advised that the requirements of this guideline will be strictly enforced. Systems that do not meet the requirements of the guideline as outlined below will not be accepted.

3.1.2. The contractor shall provide all controls and sequence of operations as required by these guidelines and by the drawings. Provide all required devices, sensors, hardware, software, wiring, controllers, etc. including any required and not specifically addressed in this guideline but required for system functionality. It shall be the responsibility of the contractor to provide a complete and functional system.

3.2 Hardware

3.2.1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135 (latest), and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.

3.2.2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135 (latest).

3.2.3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135 (latest), and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.

3.2.4. Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135 (latest), and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.

3.2.5. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135 (latest), and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.

3.2.6. Controllers shall implement the full ANSI/ASHRAE 135 BACnet protocol (latest). Controllers must meet all of the requirements of this standard and must adhere to all of the protocol definition set forth by ANSI. All controllers shall be able to co-exist and interoperate on the BACnet network without interfering or limiting other controller’s functionality. Controllers shall be able to be installed by any standard BACnet Network Services based network management tool.

3.2.7. Vendor to install BAS on city’s server. A local Personal Computer may be installed on site by the City of Brampton to help aid system configuration and monitoring. Under no circumstances shall the PC be used as a control device for the network. It can be used for storage of data, network management, and as a GUI. If the PC is taken off line, the control system shall continue to operate fully.

3.2.8. Controllers shall contain non-volatile memory for storage of control programs, configuration, and set-points. All such data shall be retained in the event of a power failure. At least one controller shall have an on-board (battery or “super cap” backed) real-time clock to ensure correct time-of-day operation following a power failure. Controllers that are not backed-up in the event of a power failure and that require time based operation (VAV’s, heat pumps, etc.) shall be peers on the network and be able to obtain time synchronization from a power fail protected controller and/or controllers upon network power restore

3.2.9. BACnet devices

1. Only BACnet certified devices will be accepted on the control network. BACnet compatible, BACnet compliant, and variations for controllers are not acceptable. Refer to table 7.6 on what points to be accessible through BAS using BACnet integration
2. Any controller that does not meet this guideline must be stated and submitted with specific reason why it is not BACnet certified.
3. Any custom software required for controller programming shall be included as a leave-behind tool with enough license capability built into the bid to support the installation. If configuration tool not allowed to leave behind, equipment is not to be specified or installed. Refer to Appendix A, Table 9.6 regarding what points are to be accessible through BAS using BACnet integration

3.2.10. Incorporate Uninterruptible Power Supply surge transient protection in the installation of the system to protect electrical components in all BACnet controllers, remote controllers, and operator's workstations.

3.3 Network

3.3.1. BACnet routing shall be performed by BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

3.3.2. Each SS and SA shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using MS/TP (minimum speed of 78.8 kbps) Data Link/Physical layer protocol.

3.3.3. IP switches will be specified by City of Brampton Digital Innovation Team. BAS vendor to contact City of Brampton Digital Innovation Team Department.

3.3.4. Vendor to use existing CoB Virtual servers.

3.3.5. MS/TP network design

1. Each ASC and AAC shall reside on a BACnet network using the MS/TP (minimum speed of 78.8 kbps) Data Link/Physical layer protocol.

3.4 IP Network design

1. Each ASC and AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing.

3.5 Open Protocol

3.5.1. New and existing installations use BACnet for all aspects of communication, including workstation, field panel, custom application controller and unitary controller communications and are commonly referred to as native BACnet systems.

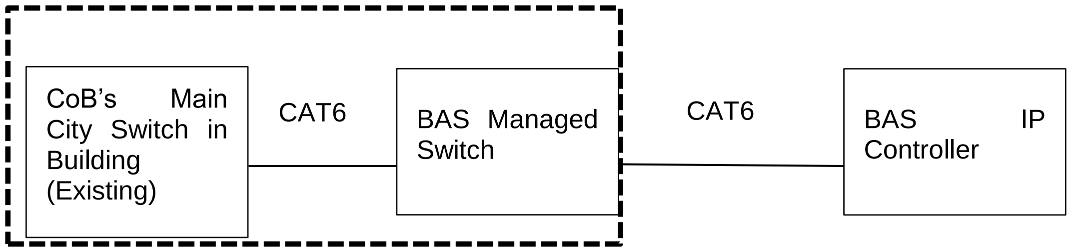
3.5.2. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

3.5.3. Provide BACnet based products that communicate on multiple channels to meet the functional guidelines as indicated on the Drawings and the dedicated product functional guidelines and profiles specified in other sections.

3.5.4. Provide BACnet/IP routers and repeaters as required to combine different communication channels onto a central field bus or as required to segment groups of Intelligent Devices and/or Control Units.

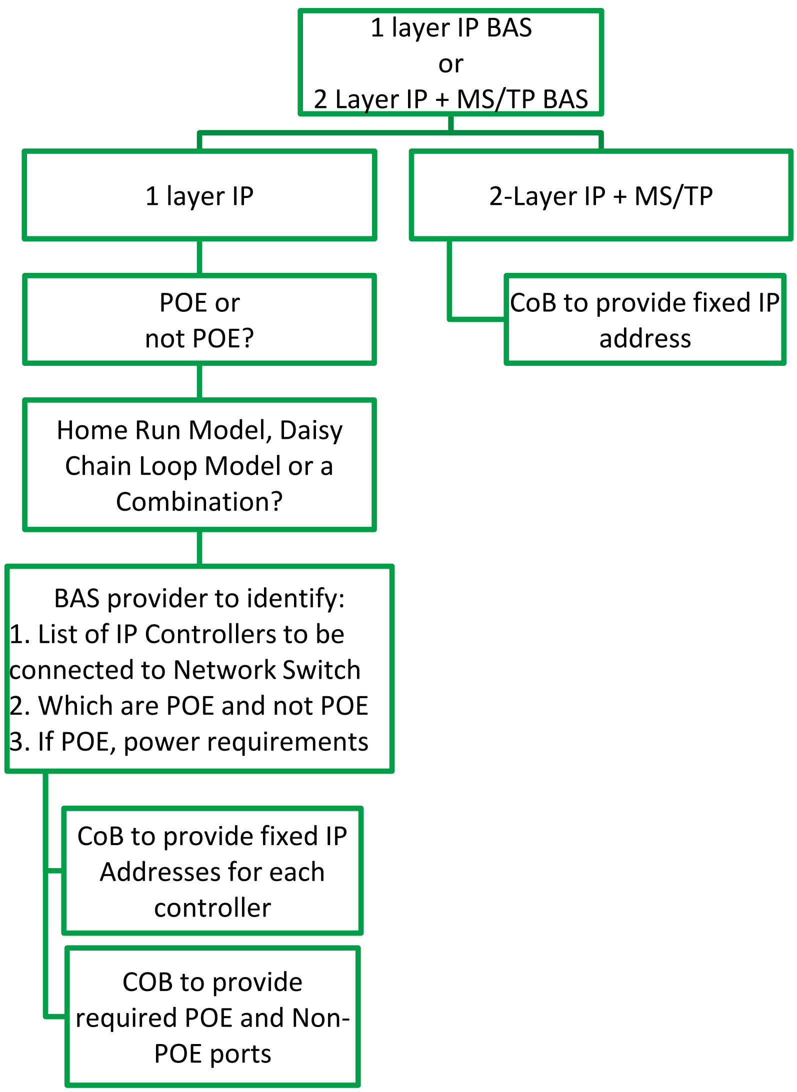
3.5.5. BACnet address should not be duplicated with any of the existing equipment city wide. Correct any issues with conflicting BACnet addresses on the City Network and verify with EMG for any available BACnet addresses. If the equipment is open to the network name the unit (site location/equipment name).

3.5.6. IP drops will be provided by the BAS contractor, but part of the design and selection of the equipment will be done by the City of Brampton as defined in schematic below. The cost of the entire scope to be under BAS contractor.



Specified and installed by COB Installed by BAS Contractor

3.5.7. IP addresses will be provided by City of Brampton Energy Management group. Vendor to coordinate with city.



3.5.8. The wireless field bus system shall employ ZigBee 3.0 or the latest technology to create a wireless mesh network that provides wireless connectivity for BACnet devices at multiple system levels. Controls installer shall verify wireless network performance including online status verification and signal strength for all wireless connected devices and provide a printed report detailing network and wireless device status. All wireless devices shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems. Wireless devices shall be FCC compliant to CFR Part 15 subpart B Class A. Wireless devices shall operate on the 900MH / 2.4 GHZ ISM Band. (Not all BAS systems utilize wireless controls so please contact City of Brampton's Energy Management Group for further direction on wireless implementation).

3.6 Wiring and Raceway

3.6.1. Provide wire, raceway systems, 24 VDC and/or 24 VAC power supplies and final connections to nodes provided by this contract. Must comply with electrical (Division) requirements.

3.6.2. BAS Vendor to coordinate with Digital Innovation Team department to ensure all color coding matches City of Brampton's standards.

3.6.3. Conduit to be installed to accommodate the space conditions. Electrical metallic tubing EMT with compression type fittings in dry locations; cold rolled steel zinc coated or zinc coated rigid steel with threaded fittings in wet locations or where exposed to weather, such as, but not limited to the case with rooftop units. In special areas with potential exposure to chemicals, such as, but not limited to pools, install site-specific conduit

3.7 User Interface/Operator Work Station (OWS) Hardware and Telecommunication Protocols

3.7.1. City of Brampton's Digital Innovation Team department has a life cycle standard program for all Hardware and software pertaining to PC, laptop, printer and other work station's hardware. BAS Contractor is to follow the Digital Innovation Team (CoB) guidelines/guidelines for hardware, printer(s), software and telecommunications protocols.

3.7.2. Project Manager, Project Coordinator and Digital Innovation Team's Project Manager will validate the supply and installation of workstation(s) and peripheral devices.

3.8 Temperature Sensors

3.8.1. Temperature sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.

3.8.2. Strap-on mountings shall not be permitted.

3.8.3. Outdoor installations shall be of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel. In special areas with potential exposure to chemicals, such as, but not limited to pools, install site-specific enclosures.

3.8.4. Thermostats to be installed on the north wall or shaded from direct sunlight.

3.8.5. Sensors shall be with enclosure where located in finished space.

3.8.6. Sensors not to be installed close within close proximity to a diffuser.

3.8.7. Sensors in ducts shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces or positions obstructed by ducts, equipment, and so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element. Ducts shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.

3.8.8. All sensors measuring temperatures in pipes larger than 2 inches in diameter or in pressure vessels shall be supplied with wells properly fabricated for the service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand pressures and velocities to which they are subjected. Wells shall be installed in the piping at elbows where piping is smaller than the length of the well to affect proper flow across the entire area of the well.

3.9 Graphical Requirements

3.9.1. Main Screen to have 3D image of the building with each floor identified and clickable. On the bottom of the screen, all major base-building units to be listed and upon selection, will navigate the user to that system's graphics

3.9.2. Summary screen of the main base-building items and analytics

3.9.3. Summary screen of all the field equipment

3.9.4. All sequence of operations will be on the graphics. It will be an individual screen that will be accessible through a clickable icon on the graphics page of its associated unit.

3.9.5. Alarms to be visible in a separate pane at all times

3.9.6. A tree structure on a pane always visible will provide the hierarchy of all units on the BAS. This is to be the main navigation bar and will be use to quick-navigate to any unit.

3.9.7. Each floor plan will be shown on the graphics. The floor plans will indicate the Terminal Units serving the areas and include the Terminal Unit's setpoints and current temperature. Additionally, each floor plan will be color coded to represent the AHUs serving the field equipment. This color code will be provided as a legend on the graphics.

3.9.8. Typical AHU graphics will include the name of the unit and what it serves on the top of the page. The AHU will show all its input/output points on the graphics and will also include the setpoints. OAT will be shown on the top right.

3.9.9. Field units such as, but not limited to, VAV, Radiators, and Heat Pumps to display an image of the unit and any associated equipment. All controls parameters to be displayed on the page in an orderly fashion.

3.9.10. Main Heating and Cooling system to have a dedicated graphics page.

1. In the cooling system, the evaporator side to be blue, with the supply, colder fluid being a lighter shade. In the condenser side, green color is to be used, with the cooler fluid return from the heat rejection to be a lighter shade.
2. In the heating system, red is to be used. The return, colder fluid is to be a lighter shade of red.
3. Lighter shade always to mean colder

3.9.11. All input/output points to be displayed on the graphics and will also include the setpoints.

3.9.12. Anything that is in normal operation will be in black text. Anything that is in manual override or alarm will be in red.

3.9.13. Trend logs should also be visible from the main graphics screen.

3.9.14. The entire network architecture to be provided on the graphics.

Chapter 4. **Execution Guidelines**

4.1 Strategical Meetings

4.1.1. BAS Vendor to schedule meetings at all milestones with the departments listed in Section4 to ensure all milestone are captured.

4.1.2. Kick-Off meeting with the owner to discuss applicable items

1. Timelines and deliverables
2. Integration with other base-building systems
3. Network Infrastructure
4. Basic versus Advanced Energy Management requirements
5. If existing building, discuss with Building Operator minimum requirements

4.1.3. Strategic Meeting with building stakeholders

1. Life Safety Guideline. Inquire about what are some life safety guidelines we should incorporate into the BAS design.
2. Discuss energy efficient sequences and their applicability to building requirements.

4.1.4. Coordination meeting with Commissioning Agent

1. Commissioning Agent to be involved with the project at all milestones.

4.2 Cabinets

4.2.1. All supervisory controllers to be installed in cabinets.

4.2.2. Cabinets must be in accessible spaces, such as, but not limited to closets, mechanical rooms allowing for operator to easily work on the system.

4.2.3. Controllers and Cabinets must be clearly marked and identified on control drawings.

4.2.4. Each cabinet must have a set of control drawings and sequence of operations specific to the systems it's controlling.

4.3 Tagging and Identification

4.3.1. Automatic Control Valve Tags

1. For valves, etc., use metal tags with a 2-inch minimum diameter, fabricated of brass, stainless steel or aluminum. Attach tags with chain of same materials. For lubrication instructions, use linen or heavy duty shipping tag.
2. Tag valves with identifying number and system. Number valves by floor level, column location and system served.
3. Prepare lists of all tagged valves showing location, floor level, and tag number use. Prepare separate lists for each system. Include copies in each maintenance manual.

4.4 Wire Tags

4.4.1. Vendor to contact with City of Brampton Digital Innovation Team to accommodate wiring standards and colors.

4.4.2. Wires will be labelled with controller instance number, point type and number and brief definition. For example: 10110.AI4.SAT

4.4.3. Conduit Tags and Equipment

1. Provide tagging or labeling of conduit so that it is always readily observable which conduit was installed or used in implementation of this work.

4.4.4. Miscellaneous Equipment Identification

1. Screwed-on, engraved black lamacoid sheet with white lettering on all control panels and remote processing panels. Lettering sizes subject to approval.
2. Inscription (subject to review and acceptance) indicating equipment, system numbers, functions and switches. For panel interior wiring, input/output modules, local control panel device identification.

4.5 Testing and Commissioning

4.5.1. Provide field calibration, testing and commissioning of equipment as specified herein.

4.5.2. Provide detailed start-up and system commissioning report (three copies) to the client. A third password

4.5.3. Commissioning agent (CA) will commission (CX) the entire new system. The CA will provide the detailed report to the consultant/engineer for review. The CX report shall be reviewed and stamped by the consultant/ engineer to ensure that system is commissioned properly and quality is maintained as per client’s guide lines and standards.

4.6 Instruction of Owner Operating Personnel (Operator’s Training)

4.6.1. All training shall be by the Controls Contractor and shall utilize specified manuals, as-built documentation, the on-line help utility and any other appropriate training materials. Operator training shall include:

1. Two (2) initial eight (8)-hour sessions for a group of four (4) people.

4.6.2. The initial operator-training program shall be to establish a basic understanding of functions, commands, routines, etc. and shall assume attendees have a sound working knowledge of the Windows operating system and PC use. The training shall encompass as a minimum:

1. Troubleshooting of input devices (i.e. bad sensors)
2. Sequence of operation review
3. Trends
4. Logic
5. Sign on - sign off
6. Selection of all displays and reports
7. Commanding of points (keyboard and mouse mode)
8. Modifying label text
9. Use of all dialogue boxes and menus
10. System initialization
11. BACnet Network Management Software (if applicable)

4.6.3. Provide a single software tool for setting up the system and configuring the operator/user interface. System and user interface functions shall include system command capability, system monitoring, system diagnostics and data archiving

4.7 Preventative Maintenance

4.7.1. There will be an ongoing list where the building operators will identify issues pertaining to the BAS. The BAS vendor is to only address these issues during the preventative maintenance.

4.7.2. The BAS vendor will provide list of corrected issues at the end of the preventative maintenance visit, which will be signed off by the building operator. If a Building Operator sign off is not provided, invoice of preventative maintenance will not be approved.

4.7.3. Maintenance contractor to provide report on the same day for invoices to be approved

4.7.4. Issues to be filled in the following template

Building	Unit	Issue

4.8 Disposal of material

4.8.1. BAS vendor to contact the Energy Management team to coordinate what is to be done with the redundant material that will be disposed. For example, controllers, actuators, sensors, etc.

Chapter 5. Contact Information

This is a list of contact information within the City of Brampton that has been referenced in this guideline.

Reference	Department	Role to Contact
Energy Management Team	Facilities Operations & Maintenance	Project Coordinator, Energy Management
Asset Management Team	Facilities Operations & Maintenance	Advisor, Asset Management
Digital Innovation and Technology	Digital Innovation and Technology	Project Manager

Chapter 6. Schedule of Responsibilities

The following schedule identifies the responsible Division for the installation of the facility automation system and should be used as a general guide. The General Contractor is the central authority governing the total responsibility of all trade contractors. Therefore, deviations and clarifications of this schedule are permitted provided the General Contractor assumes responsibility to coordinate the trade contractors different than as indicated herein. If deviations or clarifications to this schedule are implemented, submit a record copy to the Architect.

	Item		**Furnish by:**	**Install by:**	**Power by:**	**Control wiring by:**
1	Equipment Motors		M	M	E	---
	Magnetic Motor Starters:					
2	A)	Automatically controlled with or without HOA switches	E	E	E	TCC
3	B)	Manually controlled	E	E	E	---
4	C)	Manually controlled, and which are furnished as part of factory wired equipment	M	M	E	E
5	D)	Special duty type (part winding, multi-speed etc.)	M	See note 1	E	See note 1
6	E)	Adjustable frequency drives with manual bypass	TCC	TCC	E	See note 2
7	F)	Domestic booster pump motor controls	M	M	E	TCC
8	General equipment disconnect switches, thermal overload switches, manual operating switches		E	E	E	---
9	Sprinkler system water flow and tamper switches		M	M	E	---
10	Outside fire alarm horn and light (at Siamese connection)		M	M	E	---
11	Line voltage contactors		E	E	E	TCC
12	Control relay transformers (other than starters)		TCC	TCC	E	TCC
13	Main fuel oil tank alarms (high and low level) and remote indicating lights		M	M	TCC	TCC
14	Day tank fuel oil alarms (high and low level) and remote indicating lights		E	E	E	TCC

	Item		Furnish by:	Install by:	Power by:	Control wiring by:
15	Line voltage control items (e.g.: line voltage t-stats not connected to control panel		M	E	E	E
16	Loose control and instruments furnished as part of the mech. Equip. or		M	M	M	M
17	Control and instrumentation panels		TCC	TCC	E	TCC
18	Automatic control valves, automatic dampers and damper operators/actuators,		TCC	M	E	TCC
19	Duct type fire and smoke detectors including relays for fan shut-down		TCC	TCC	E	TCC
20	Contactors for cooling tower basin heaters		M	M	E	M
21	Mechanical piping heat trace (inc. relays, contactors, t-stats etc.)		M	M	E	M
22	Emergency-Power-Off (EPO) shutdown push-button(s), (break-glass station) and		M	M	M	M
23	Control interlock wiring or software bindings between chillers, pumps and cooling		TCC	TCC	E	TCC
24	Electric radiant heating panels, un-ducted electric unit heaters and cabinet		E	E	E	E
25	Airflow control device with transmitter		TCC	M	E	TCC
26	Air terminal devices (e.g. VAV boxes)		M	M	E	TCC
	Intelligent devices and control units provided with mechanical equipment such as, but not limited to:					
27	A)	Valve and damper operators	M	M	E	TCC
28	B)	Heat pumps, AC units	M	M	E	TCC
29	C)	Fan coil units	M	M	E	TCC
30	D)	Air terminal units	M	M	E	TCC
31	E)	Boilers, Chillers, etc.	M	M	E	TCC
	Intelligent devices and control units provided with electrical systems such as, but not limited to:					
32	A)	Occupancy/motion sensors	E	E	E	TCC

	Item		Furnish by:	Install by:	Power by:	Control wiring by:
33	B)	Lighting control panels	E	E	E	TCC
34	C)	Switches and dimmers	E	E	E	TCC
35	D)	Switch multiplexing control units	E	E	E	TCC
36	Door Entry Control units		TCC	TCC	E	TCC
37	Gateway for protocol conversion with non-BACnet/ WAN based systems		TCC	TCC	TCC	TCC
38	Routers, bridges and repeaters		TCC	TCC	TCC	TCC
	Abbreviations:					
39	E	Electrical Contractor				
40	M	Mechanical Contractor				
41	Power	Power wiring connection, low and medium voltage				
42	TCC	Temperature Controls Contractor				

Notes to Schedule of Responsibilities:

I. *Magnetic motor starters (special duty type) shall be set in place under electrical division except when part of factory wired equipment, in which case set in place under mechanical division.*

II. *Where a remote motor disconnect is required in addition to the one provided integral to an Variable Frequency Drive (VFD), the Controls Contractor shall provide the necessary control interlock between the disconnects.*

III. *The Controls Contractor shall inform the Mechanical Contractor and the Electrical Contractor of the additional capacity required of control power transformers.*

IV. *The Mechanical Contractor shall refer to the electrical specifications and plans for all power and control wiring and shall advise the Architect of any discrepancies prior to bidding. The Controls Contractor shall be responsible for all control wiring as outlined, whether called for by the mechanical or electrical drawings and specifications.*

Chapter 7. Abbreviations

AAC	Advanced Application Controller		
AGC	Application Generic Controller	**GUI**	Graphical User Interface
ASC	Application Specific Controller	**HVAC**	Heating, Ventilating and Air
AWS	Advanced Workstation		Conditioning
BAS	Building Automation System	**ITC**	Intermediate
BMS	Building Management System		Telecommunications Closet
B-BC	Building Controllers	**I/O**	Input/Output
B-AAC	Advanced Application Controllers	**IP**	Internet Protocol
B-ASC	Application specific controllers	**WAN**	Wide Area Network
B-SS	Smart Sensors	**NSS**	Network Services Server
B-SA	Smart Actuators	**NSI**	Network Services Interface
CA	Commissioning Agent	**NFPA**	National Fire Protection
CAC	Custom Application Controller		Association
CoB	City of Brampton	**OI**	Operator interface
COS	Change of State	**OS**	Operating System
CPU	Central Processing Unit	**OWS**	Operating Work Station
CX	Commissioning	**PE**	Pneumatic-electric
DDC	Direct Digital Controller	**PID**	Proportional Integral Derivative
		POE	Power over Ethernet
DPR	Damper	**PRV**	Pressure Reducing Valve
DPU	Digital Point Unit	**PSI(g)**	Pounds per square inch (gauge)
DRF	Device Resource File	**RAM**	Random Access Memory
DWGS	Drawings	**SCADA**	Supervisory Control and Data
EMCS	Energy Monitoring Control System		Acquisition System
EP	Electric-pneumatic	**TCS**	Temperature Control System
FAS	Facility Automation System	**TCC**	Temperature Control Contractor
FPB	Fan Powered VAV Box	**UL**	Underwriters' Laboratory
FPM	Feet per minute	**VAV**	Variable Air Volume
FACP	Fire Alarm Control Panel	**VCS**	Voice Communication System
FCC	Fire Command Center	**WC**	Water Column
FMS	Fire Management System	**XIF**	External Interface File
GPM	Gallons per minute		

Chapter 8. Building Automation System Design Checklist

8.1 Best Practices - Building Automation Systems Design Checklist (Office facilities)

Equipment Description	BAS Function/Strategy	Outside air temp	Water temperature	Space temperature	Burner control	Pump control	Supply air temperature	Mixed air temperature	Htg & clg coil valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Humidity Control	Chiller output control	Slide valve position feedback	System suction pressure	System head pressure	Lighting control	Photo sensor	Snow Sensor
Hot water boilers	Reset water temperature.	✓	✓																		
	Boilers to run in lead/lag function switching every Tuesday to ensure equal runtime. Alternatively, utilize boiler manufacture sequencer.				✓																
	Ensure complete modulating control or proper hi-low control.				✓																
	Maintain one setpoint and stage using time interval rather than error from setpoint..		✓		✓																
	Stop circulating water through non-firing boilers.					✓															
Heating water	Reset water temperature with outside air temperature.	✓	✓																		
	Reset water temperature from building space temperatures	✓		✓																	
Air systems	Supply air temperature reset from outside air temperature.	✓					✓		✓	✓											
	Trim supply air temperature setpoint with feedback from spaces.			✓			✓		✓	✓											
	Mixed air control - calculate and control to minimum ventilation	✓								✓	✓										
	Integrated economizer (provide required supply air temperature)						✓	✓		✓											
	Scheduling - minimize scheduled time											✓									
	Scheduling - optimal start	✓		✓					✓	✓		✓									
	Scheduling - no outside air when systems operate in unoccupied hours	✓		✓					✓	✓		✓									
	Occupancy sensing - operate fan or open outside air dampers only when occupied	✓		✓						✓		✓	✓								
	Set relative humidity to minimum required. As per ASHRAE guidelines, 30% min (Winter), 60% max (Summer).													✓							
	Reset humidity at very low temperatures	✓												✓							
	Space pre-cool (morning)	✓		✓					✓	✓		✓									
DHW	Schedule recirculation pump for occupied periods only					✓															
	Reduce setpoint to minimum required temperature initially set at 60C		✓																		
	Profile tank water temperature - reduced temperatures will reduce recirculation heat loss		✓																		
	If tank separate from heater, do not circulate water through non-firing heater		✓			✓															
Cooling	Reset supply water temperature up if building systems are not variable flow		✓												✓						
	Shut off chiller when no cooling required	✓		✓											✓						
	Shut off chilled water pumps when cooling not required	✓		✓																	
	Sequence operation of different size chillers to optimize operation		✓												✓						
	Sequence operation of different size cooling towers to optimize operation.		✓									✓									
	Sequence lead-lag operation of cooling towers to operate at best efficiency.		✓									✓									
Zone control	Occupancy sensing to shut off constant volume or variable volume boxes plus lights.			✓									✓						✓		
Lighting**	Schedule																		✓		
	Photo sensor control																		✓	✓	
Snow melting	Use snow sensor				✓																✓
Outdoor lighting	Schedule																		✓		
	Trim schedule using photo sensor																		✓	✓	

Equipment Description	BAS Function/Strategy	Outside air temp	Water temperature	Space temperature	Burner control	Pump control	Supply air temperature	Mixed air temperature	Htg & clg coil valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Humidity Control	Chiller output control	Slide valve position feedback	System suction pressure	System head pressure	Lighting control	Photo sensor	Snow Sensor
	Trim schedule using sunset-sunrise calculation																		✓		

8.2 Best Practices - Building Automation Systems Design Checklist (Recreational Pool)

Equipment Description	BAS Function/Strategy	Outside air temp	Water temperature	Space temperature	Burner control	Heat exchanger control	Pump control	Supply air temperature	Htg & clg coil valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Space humidity sensor	Lighting control	Photo sensor	Turbidity sensor
Pool circulation pump	Speed modulation based on turbidity						✓										✓
Pool water heater	Reset of pool heating water temperature based on usage		✓			✓											
Air system	Start/stop based on weekly schedule and humidity sensors											✓		✓			
	Supply air temperature reset from outside air temperature.	✓						✓	✓	✓							
	Trim supply air temperature setpoint with feedback from spaces			✓				✓	✓	✓	✓						
HID Lighting	Occupancy sensors used for dimming, if Hi-Lo ballasts installed.												✓		✓		
DHW heaters	Start/stop and modulated firing controls, minimize short cycling of heaters.				✓												
DHW recirculation pumps	Start/stop based on weekly schedule with override based on flow switch						✓										
Hot Water Boilers	Start/stop and modulated firing controls, minimize short cycling of heaters. Minimum runtime of 15minutes				✓												
Heating Water circulation	Start/stop interlock with boiler and programmable delay				✓		✓										
Unit Heaters	Programmable setpoint thermostats with occupancy override												✓				
Heating water convectors	Programmable setpoints thermostats with occupancy override			✓		✓							✓				

8.3 Best Practices - Building Automation Systems Design Checklist (Arenas)

Equipment Description	BAS Function/Strategy	Outside air temp	Water temperature	Space temperature	Burner control	Pump control	Supply air temperature	Mixed air temperature	Htg & clg coil valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Chiller output control	Slide valve position feedback	System suction pressure	System head pressure	Lighting control	Photo sensor	Ice temperature	Brine heat exchange control	CO2 sensor
Ammonia Compressors	Reset suction pressure using brine temperature setpoint		✓													✓						
	Optimize staging using slide valve position/compressor loading													✓	✓							
	Optimize staging by varying permissible suction pressure differential													✓		✓						
	Optimize staging using load bias (varying sized compressors/condensers)													✓	✓							
Glycol brine circ. pumps	Start-stop using ice temperature					✓														✓		

Equipment Description	BAS Function/Strategy	Outside air temp	Water temperature	Space temperature	Burner control	Pump control	Supply air temperature	Mixed air temperature	Htg & clg coil valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Chiller output control	Slide valve position feedback	System suction pressure	System head pressure	Lighting control	Photo sensor	Ice temperature	Brine heat exchange control	CO2 sensor
	Schedule with activities					✓																
Glycol/brine heat exchanger	Reset ice temperature with scheduled activities			✓																✓	✓	
	Optimize start for scheduled activities			✓																		
	Schedule with occupancy/photocell override			✓									✓						✓			
Evaporative condenser fans	Reset condenser water temperature using outside air temperature	✓	✓																			
	Reset head pressure using outside air temperature	✓															✓					
	Optimize staging based on two-speed/variable speed fans										✓											

8.4 Best Practices - Building Automation Systems Design Checklist (Arenas) Continued

Equipment Description	BAS Function/Strategy	Outside air temp	Water temperature	Space temperature	Burner control	Pump control	Supply air temperature	Mixed air temperature	Htg & clg coil valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Chiller output control	Slide valve position feedback	System suction pressure	System head pressure	Lighting control	Photo sensor	Ice temperature	Brine heat exchange control	CO2 sensor
Lighting	Schedule with activities - minimize operating hours																	✓				
	Schedule with activities - use occupancy sensors to optimize												✓					✓				
	Schedule HID Hi/Low dimming with activities - minimize operating hours																	✓				
	Schedule HID Hi/Low dimming with activities - use occupancy sensors to optimize												✓					✓				
DHW	Schedule recirculation pump for occupied periods only \					✓																
	Reduce setpoint to minimum required temperature		✓		✓																	
	Profile tank water temperature-lower temperatures will lower recirculation heat loss		✓		✓																	
	If tank separate from heater, do not circulate water through non-firing heater		✓			✓																
	Maximize on-time by 1st on 1st off				✓																	
Gas-fired infrared heaters	On-off using programmable blackbody thermostats			✓	✓																	
	On-off using programmable blackbody 'stats & occupancy sensor			✓	✓								✓									
Exhaust fans	Schedule											✓										
	Occupancy override to schedule											✓	✓									
Supply air systems	Scheduling - minimize scheduled time											✓										
	Occupancy override to schedule											✓	✓									
	Scheduling - optimal start	✓		✓					✓			✓										
	Control outside air volume to occupancy requirement using CO2						✓															✓

Equipment Description	BAS Function/Strategy	Outside air temp	Water temperature	Space temperature	Burner control	Pump control	Supply air temperature	Mixed air temperature	Htg & clg coil valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Chiller output control	Slide valve position feedback	System suction pressure	System head pressure	Lighting control	Photo sensor	Ice temperature	Brine heat exchange control	CO2 sensor
	Integrated economizer	✓					✓	✓		✓	✓											
	Trim supply air temperature setpoint from space temperature			✓			✓															

8.5 Integration Matrix

M = monitor, C = Command and Control, S = Scheduling

	Building Automation	Lighting Control	Existing Metering (ele,H2O,gas)	Emergency Power	Fire Alarm	Access Control	Video Surveillance	Intercom	Mobile Alert System	Parking Control	Digital Signage/Advertising	Elevators	Public lobby WiFi	**Visualization – single pane of glass**	Fault Detection& Diagnostics	Building Engines - Tenant Engagement	Building Engines – Work Orders
Building Automation																	
Lighting Control	**C**																
Existing metering (ele, H2O, gas)	**M**																
Emergency Power	**M**																
Fire Alarm	M			M													
Access Control																	
Video Surveillance						**C**											
Intercom						**C**	**C**										
Mobile Alert System						**C**	**C**	C									
Parking Control																	
Digital Signage / Advertising																	
Elevators				C	C												
Public lobby WiFi	**M**																
Visualization – Single Pane of glass	**C/S**	**C/S**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		**M**	**C/S**	**C**				
Fault Detection/Diagnostics	M	**M**	**M**	**M**										**M**			
Building Engines - Tenant Engagement	**S**	**S**									**M**	**C/S**					
Building Engines – Work Orders	**C**	**C**									**M**				**C**	C	

8.6 Point List Chart

	Outside air temp	Supply Water temperature	Return Water Temperature	Space temperature	Burner control	Chiller/Comp control	Pump control	Supply air temperature	Mixed air temperature	Unit Heating valves	Unit Clg Valves	Building Htg valves	Building Clg Valves	Damper control	Return air temperature	Fan control	Occupancy sensor	Building Schedule	Slide valve position feedback	suction pressure	System head pressure	Ice temperature	Brine HX Controller	CO2 sensor	VFD on pumps	VFD on fans	Status, kW Consumption, Fault Code on station	Alarms			
																												Deviation from Setpoint	Pump/Fan Command vs Status	Time Delay (Minutes)	Priority
BOILER PLANT	B	B	B		B		B											B	P						P			10%	Y	10	HIGH
CHILLER PLANT	B	B	B			B	B					B	B					B	P						P			10%	Y	10	HIGH
RTU	V			V	V	V		B	V	V	V			V	V	B	P	P	V					P		P		20%	Y	10	MEDIUM
AHU	B	P	P				B	B	B	B	B			B	B	B	P	B	P					P	P	P		20%	Y	10	HIGH
DHW	B	B	P				B																		P			5%	Y	10	MEDIUM
VAV	B			B				P	P			B	B	B	P	B	P	B						P				10%		10	LOW
SNOW MELTING	B					B												B							P			5%	Y	10	HIGH
POOL CIRCULATION AND WATER HEATER	B	B	P	B	B		B			V							B	B							P			10%	Y	10	HIGH
AMMONIA COMPRESSOR	B	B	P	B		B	B			V	V									V	V	B	B		P			5%	Y	10	HIGH
HEAT EXCHANGERS	B	B	P x3				B			B															P			10%		10	MEDIUM
EVAPORATIVE CONDENSER FANS	B	B	B				B			B				P		B		B	P						P	P		15%	Y	10	MEDIUM
HEATPUMP	B	B		B		B										B	P	B						P		P		10%	Y	10	MEDIUM
RADIATORS	B	B	P	B			P			B							P	B						P				15%		10	MEDIUM
OIL RECEPTORS																													Y	10	LOW
LOCAL AC UNITS	P/V			B		P/V	P/V	P/V								P/V	B		P/V					P/V		P/V		10%	Y	10	LOW
EV CHARGING STATIONS																											B				

B – Basic Points to be included in all designs as a minimum

P – Premium Points to be included as required based on building's goals

V – Virtual Monitoring through integration (BACnet, MODbus)

This has been left intentionally blank.