Request for Tender # T-1160-2021
for
Construction of New Seaton Paramedic Station and Training Facility in the City of Pickering

Appendix D, D-1

The Deliverables and Material Disclosures

Project Manual - Volume 2 of 2

Electronic submission required

The Regional Municipality of Durham
Works Department
605 Rossland Road East, Whitby ON, L1N 6A3

New Seaton Paramedic Station and Training Facility
1890 Fifth Concession Rd, Pickering, Ontario

AECOM Canada Ltd.
50 Sportsworld Crossing Road, Suite 290, West Entrance, Kitchener, Ontario, N2P 0A4, Canada
Project No. 60611569

These specifications (Divisions 00-33) were prepared under the supervision of the following registered coordinating professionals:

Written by: **Jared Cardiff** **Date:** **September 22, 2021**

Checked by: **Jason Chang** **Date:** **September 22, 2021**
(Consultant Project Manager)

Architectural	Electrical	Mechanical
ONTARIO ASSOCIATION OF ARCHITECTS 22.9.2021 ROY HOWARD TURNER LICENCE 4845	LICENSED PROFESSIONAL ENGINEER Sep 21, 2021 W.E. MOHAMED ALI 100186996 PROVINCE OF ONTARIO	LICENSED PROFESSIONAL ENGINEER SEP 22, 2021 R. G. CARKNER 100162393 60611569 PROVINCE OF ONTARIO
Structural	**Civil**	**Landscape**
LICENSED PROFESSIONAL ENGINEER K.T.D. DUONG 100055126 9/22/2021 PROVINCE OF ONTARIO	LICENSED PROFESSIONAL ENGINEER S.T. MAYIROU 100147402 2021/09/20 PROVINCE OF ONTARIO	ONTARIO ASSOCIATION OF LANDSCAPE ARCHITECTS Derek Weekers OALA 2021/09/22 MEMBER
Geothermal		
LICENSED PROFESSIONAL ENGINEER S.M.R. ALMEIDA 100161229 Sept 22/21 PROVINCE OF ONTARIO		

VOLUME 1 of 2

Division 00 Procurement and Contracting Requirements

00 01 07 Seals page
00 01 10 Table of contents
00 31 00 Available project information
Preliminary Geotechnical Investigation report
Phase One Environmental Site Assessment Update letter
Draft Soil Management Plan
Appendix A – Regional Municipality of Durham Network Standards
Appendix B – Regional Municipality of Durham Security Services Installation and Security System Standards
Appendix C – Regional Municipality of Durham Physical Protection System Installation Guidelines Checklist
00 61 14 Bonds, insurance and warranty security
00 65 36 One year extension of contract warranty period.

Division 01 General Requirements

01 11 00 Summary of work
01 14 00 Work restrictions
01 19 10 Electronic model data base
01 21 13 Cash allowances
01 25 00 Substitution procedures
01 26 13 Requests for interpretation
01 26 63 Change order procedures
01 29 00 Payment procedures
01 31 00 Project management and coordination
01 31 14 Interference and coordination drawings
01 31 19 Project meetings
01 32 00 Construction progress documentation
01 32 16 - Construction progress schedule
01 33 00 Submittal procedures
01 35 29 Health and safety procedures
01 41 00 Regulatory requirements
01 45 00 Quality control
01 50 00 Temporary facilities and controls
01 51 00 Temporary utilities

01 52 00 Construction facilities
01 53 00 Temporary construction
01 55 00 Vehicular access and parking
01 57 13 Temporary erosion and sediment control
01 61 00 Common Product Requirements
01 62 00 Product options
01 65 00 Product delivery requirements
01 74 00 Cleaning and waste management
01 74 19 Construction and demolition waste management
01 75 19 Testing and balancing
01 78 00 Closeout submittals
01 78 37 Extended warranties
01 79 00 Demonstration and training
01 81 13 Sustainable design criteria
Appendix A – CAPP Inspection Log (Schedule C1)
Appendix B – Low-Emitting Materials Reporting Form
Appendix C – BPDO Materials Reporting Form
Appendix D – LEED Checklist
01 81 19 Construction IAQ requirements
Appendix A – Schedule Q1 – General Contractor IAQ Checklist & Log
Appendix B – Schedule Q2 – Mechanical Contractor IAQ Checklist & Log
01 91 00 General Commissioning Requirements
Durham Region Seaton Paramedic Services – Commissioning Plan

Division 02 Existing Conditions
Not used

Division 03 Concrete
03 10 00 Concrete formwork and falsework
03 20 00 Concrete reinforcing
03 30 00 Cast-in-place concrete
03 35 00 Concrete finishing

Division 04 Masonry
04 21 13 Brick veneer masonry
04 22 00 Concrete masonry units
04 41 13 Gabion stone cladding

Division 05 Metals
05 12 23 Structural steel for buildings
05 21 00 Steel joist framing
05 31 00 Steel decking
05 40 00 Cold formed metal framing
05 50 00 Metal fabrications

Division 06 Wood, Plastics, and Composites
06 10 00 Rough carpentry
06 40 23 Interior architectural woodwork
06 61 16 Solid surfacing fabrication

Division 07 Thermal and Moisture Protection
07 14 16 Cold fluid-applied waterproofing
07 21 00 Thermal insulation
07 26 16 Below-grade vapour retarders
07 27 00 Membrane air barrier
07 41 13 Metal roof panels
07 46 17 Aluminum plank panels
07 46 19 Metal wall panels
07 52 23 Cold adhesive applied modified bituminous membrane
07 62 00 Prefinished metal flashing and trim
07 72 33 Roof hatches and accessories
07 84 00 Firestopping and smokeseals
07 92 00 Sealants

Division 08 Openings
08 11 13 Steel doors and frames
08 14 00 Wood doors
08 31 00 Access doors and panels
08 36 16 Aluminum framed sectional doors
08 41 13 Aluminum framed entrances and storefronts
08 44 13 Glazed aluminum curtain wall
08 70 00 Hardware
Hardware Schedule
08 80 00 Glazing
08 90 00 Fixed metal louvers

Division 09 Finishes
09 06 00 Finishes schedule
09 21 16 Gypsum wallboard
09 30 00 Tiling
09 51 13 Acoustic ceilings
09 65 00 Resilient flooring and accessories
09 67 23 Resinous flooring
09 68 13 Tile carpeting
09 84 30 Sound absorbing wall and ceiling units
09 90 00 Painting

Division 10 Specialties
10 14 00 Signage
10 14 53 Traffic signage
10 22 19 Demountable premanufactured partition systems
10 22 26 Operable partitions
10 28 13 Washroom accessories
10 44 16 Portable fire extinguishers
10 51 13 Metal lockers
10 56 13 Metal storage shelving
10 75 00 Flagpoles

Division 11 Equipment
Not used

Division 12 Furnishings
12 24 13 Roller window shades
12 31 00 Manufactured metal casework
12 48 29 Entrance mats

Division 13 Special Construction
Not used

Division 14 Conveying Equipment
Not used

VOLUME 2 of 2

Division 20 Mechanical General Requirements
20 01 00 Mechanical general requirements

20 05 00 Common mechanical work results
Mechanical electrical coordination schedule
20 05 15 Variable frequency drives
20 05 16 Piping expansion compensation
20 05 19 Gauges and meters
20 05 20 Service penetrations
20 05 29 Bases, hangers and supports
20 05 48 Vibration and noise control
20 05 49 Seismic restraints
20 05 53 Mechanical identification
20 05 55 Access doors
20 05 93 Testing, adjusting and balancing
20 07 13 Insulation for ductwork
20 07 16 Insulation for equipment
20 07 19 Insulation for piping

Division 21 Fire Suppression
Not used

Division 22 Plumbing
22 11 16 Plumbing and drainage piping
22 11 19 Plumbing and drainage specialties
22 11 23 Domestic water pumps
22 30 05 Domestic water heaters
22 42 00 Plumbing fixtures

Division 23 Heating, Ventilating, and Air Conditioning (HVAC)
23 21 13 Hydronic piping
23 21 14 Hydronic equipment and specialities
23 21 23 Hydronic pumps
23 31 00 Ductwork
23 33 00 Ductwork accessories
23 33 19 Sound attenuators
23 34 00 Fans
23 34 10 HVLS fans
23 36 00 Air terminal units
23 37 13 Grilles, diffusers and registers
23 40 00 HVAC chemical treatment

23 52 00 Heating boilers
23 57 33 Direct geo-exchange ground heat exchanger
23 70 00 Split air conditioning systems
23 72 00 Air to air energy recovery equipment
23 74 33 Dedicated outdoor air units
23 81 40 Water source heat pumps
23 82 19 Fan coil units
23 82 39 Unit heaters and force flow heaters
23 83 00 Radiant heating
23 83 13 In-slab snow melting system
23 84 13 Humidifiers

Division 25 Integrated Automation
25 01 00 Controls
25 90 01 Sequence of operation

Division 26 Electrical
26 05 00 General electrical requirements
26 05 05 Basic materials and methods
26 05 43 Electrical site services and underground ducts
26 05 73 Arc flash risk assessment
Appendix 1 – Arc Flash Risk Assessment Specification
26 09 24 BAS integrated lighting control field devices
26 12 16.01 Distribution transformers (dry type)
26 24 02 Service entrance switchboard
26 24 16.01 Panelboards and circuit breakers
26 31 00 Photovoltaic collectors
26 32 13 Diesel power generation
26 43 13 Transient voltage surge suppression
26 50 00 Lighting
26 52 00 Emergency lighting and exit signs

Division 27 Communications
27 05 00 Common work results for communications
27 51 23 Intercom and public address systems
27 53 13 Clock system

Division 28 Electronic Safety and Security
28 10 00 Card access and intrusion detection system

28 23 00 CCTV equipment
28 31 00 Fire alarm system

Division 31 Earthwork
31 05 16 Aggregates for earthworks
31 11 00 Clearing and grubbing
31 22 13 Rough grading
31 23 33 Excavation, trenching and backfilling
31 32 19.01 Geotextiles
31 37 00 Rip-rap

Division 32 Exterior Improvements
32 11 16.01 Granular sub-base
32 11 23 Aggregate base courses
32 12 16 Asphalt paving
32 14 10 Unit paving
32 15 40 Crushed stone paving
32 16 15 Concrete walks, curbs and gutters
32 17 23 Painted traffic lines and markings
32 31 13 Fabricated metal gates
32 32 35 Armourstone
32 37 00 Exterior site furnishings
32 91 19.13 Topsoil placement and grading
32 92 19.17 Terraseeding
32 92 23 Sodding
32 93 10 Trees, shrubs and ground cover planting

Division 33 Utilities
33 05 16 Maintenance holes and catch basin structures
33 05 33.13 Gravity piping
33 14 16 Water distribution piping

Division 34 Transportation
Not used

Division 35 to Division 48
Not used

End of Table of Contents

1 General

1.1 Section includes

.1 Section 20 01 00 applies to and governs the work of all Sections of Division 20, 22, 23 and 25.

1.2 Work included

.1 Products and methods mentioned or shown in the Contract Documents complete with incidentals necessary for a complete operating installation. Provide all tools, equipment and services required to do the work.

.2 Cutting and patching of new or existing work.

.3 Excavating and backfilling.

.4 Identification of equipment, piping, ductwork, and valves and controllers.

.5 Concrete equipment bases and housekeeping pads.

.6 Motors required for equipment supplied under this Division.

.7 Variable frequency drives for motors and equipment supplied under this Division.

.8 Internal wiring, relays, contactors, switches, transformers, motor starters, and all controls necessary for the intended operation, furnished with terminals and external controls suitable for connection to power source at a single easily accessed location for equipment items that are supplied with motors and/or electrical or electronic components under this Division.

.9 Take such measures and include in Bid Price for the proper protection of the existing building and its finishes at all times during alterations and construction of the new addition. Coordinate this protective work with all trades.

.10 Refer to 20 05 00 – Mechanical Electrical Coordination Schedule for extent of wiring and electrical characteristics.

.11 Verify the correct operation of each equipment item provided and/or altered and each system in total and obtain the Owner's approval prior to starting and/or returning to operation.

.12 Coordinate with all disciplines.

1.3 Related requirements

.1 Power wiring, conduit and connections for motors under this Division will be by Division 26.

.2 Power wiring, conduit and connections to variable frequency drives for motors under this Division will be by Division 26.

.3 Flashings for mechanical equipment and services located on or passing through roofs will be provided under Division 7. Supply counter flashings, and integral flashing collars on equipment and piping under this Division.

.4 Painting of exposed piping and ductwork other than for identification will be supplied under Division 09.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit names of the Balancing Agent to Consultant within one week of award of Contract.

.4 Approval Drawings: Prepare and submit drawings necessary for approval to any authority having jurisdiction, and obtain two (2) copies of approved drawings for retention by the Consultant prior to commencement of work under this Division.

.5 Shop Drawings: Prepare and submit one (1) electronic (PDF format) copy of shop drawings of major equipment items, to the Consultant for review. The Consultant will return one (1) electronic copy, marked with comments and review stamp as deemed appropriate. Prepare the necessary number of copies of the returned set and distribute to the Owner, the Prime Consultant, the General Contractor, the site, and to sub-contractors and suppliers.

.1 Clearly indicate the manufacturer's and supplier's names, catalogue model numbers, details of construction, accurate dimensions, capacities and performance. Prior to submission check and certify as correct, shop drawings and data sheets. Do not order equipment until a copy of the shop drawings, reviewed by Consultant, has been returned to Contractor.

.2 Clearly indicate the weight, location, method of support and anchor point forces and locations for each piece of equipment on shop drawings.

.3 The Consultant will not review shop drawings that fail to bear the Contractor's stamp of approval or certification.

.4 Read the following in conjunction with the wording on the shop drawing review stamp applied to each and every drawing submitted;

" The consultant's review will be for conformity to the design concept and for general arrangement only and such review shall not relieve the Contractor of responsibility for errors or omissions in the shop drawings or of responsibility for meeting all requirements of the Contract Documents unless a deviation on the shop drawings has been approved in writing by the Consultant."

.6 Contractor's Material and Test Certificates: Prepare and submit certificates for each system installed. Where certificates are prescribed by regulations, codes or standards ensure they conform to the requirements of those documents (eg. NFPA-standards). Include a copy of each certificate in the Operation and Maintenance manual. Certificates shall include the following:

.1 description of the system (description and type),

.2 description of the tests conducted and results observed, including re-testing, where necessary,

.3 description of any corrective measures undertaken,

.4 description of materials used (pipe and fittings),

.5 list of witnesses for each test conducted,

.6 date system left ready for service,

.7 signature of installing Contractor.

.7 Operations and Maintence Manual Instructions

.1 Submit Operation and Maintenance Manual in accordance with Section 01 78 00 – Closeout Submittals, and as outlined in this section. .

.2 Provide a list of names, addresses and telephone numbers of equipment suppliers, installing contractors, general contractors, architect and Consultant. Include special telephone numbers for service departments on normal and emergency call basis.

.3 Provide descriptive literature (shop drawings) of each manufactured item. Include a bill of material with purchase order numbers and vendor's identification of equipment orders for each item.

.4 Include copies of start-up reports and checklists and all certificates issued with respect to this contract.

.5 Ensure operating instructions include the following:

.1 General description of each mechanical system.

.2 Step by step procedure to follow in putting each piece of equipment into service.

.3 Schematic control diagrams for each separate mechanical system, control thermometers, freezestats, firestats, pressure gauges, automatic valves, and refrigeration accessories. Mark correct operating settings for each control device on these diagrams.

.4 Diagram of the electrical control system indicating the wiring of all related electrical components such as PE and EP switches, firestats, freezestats, fuses, interlocks, electrical switches and relays.

.5 Drawings of each control panel including temperature control and electrical panels, completely identifying all components on the panels and their function.

.6 Ensure maintenance instructions include the following:

.1 Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance and lubrication instructions.

.2 Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.

.3 Equipment directory indicating name, model, serial number and nameplate data of each item of equipment supplied, and system with which it is associated.

.4 Balancing and testing reports.

.5 Copy of valve directory.

1.5 Quality assurance

.1 Conform to the minimum requirements or better of provincial and local codes, where existing, and to the requirements of local inspection authorities for execution of work under this Division.

.2 Ensure materials supplied under this Division conform to minimum requirements and recommendations or better of applicable standards of the following:

.1 AABC Associated Air Balance Council

.2 AMCA Air Moving and Conditioning Association

.3 ANSI American National Standards Institute

.4 ASA American Standards Association

.5 ASHRAE American Society of Heating, Refrigerating, and Air Conditioning Engineers

.6 ASME American Society of Mechanical Engineers

.7 ASSE American Society of Sanitary Engineers

.8 ASPE American Society of Plumbing Engineers

.9 ASTM American Society of Testing and Materials

.10 AWWA American Water Works Association

.11 CAN2 National Standard of Canada (Published by CGSB)

.12 CAN3 National Standard of Canada (Published by CSA)

.13 CGSB Canadian General Standards Board

.14 CSA Canadian Standards Association

.15 EEMAC Electrical & Electronic Manufacturer's Association of Canada

.16 IEEE The Institute of Electrical and Electronics Engineers Inc.

.17 MSS Manufacturers' Standardization Society

.18 NBC National Building Code of Canada

.19 NEBB National Environmental Balancing Bureau

.20 NFPA National Fire Protection Association

.21 NEMA National Electrical Manufacturers Association

.22 OBC Ontario Building Code

.23 OFC Ontario Fire Code

.24 OFM Ontario Fire Marshall

.25 SMACNA Sheet Metal & Air Conditioning Contractors National Association

.26 TIAC Thermal Insulation Association of Canada

.27 TSSA Technical Standards and Safety Authority

.28 ULC Underwriter's Laboratories of Canada Ltd

.29 UL Underwriter's Laboratories (including cUL)

.3 Use latest editions and amendments in effect on date of Bid call subject to requirements of OBC.

.4 Arrange and pay for permits and inspections by authorities having jurisdiction, required in the undertaking of this Division. Make modifications required by authorities.

.5 All tradesmen employed on the project shall hold valid trade certificates/licenses and shall make a copy available for review by the Consultant and/or Owner when requested.

.6 All welding shall be executed by certified welders in accordance with registered procedures.

.7 All refrigeration work shall be executed only by mechanics with valid ODP cards.

1.6 Product delivery, handling and storage

.1 Immediately after letting of contract, review material and equipment requirements for this work, determine supply and delivery dates for all items, and notify Consultant of any potential delays in completion of this project in order that remedial action may be taken.

.2 Store neatly out of the way and protected from damage and theft, materials and equipment supplied under this Division that are received at the site by this Division.

1.7 Job conditions

.1 Visit site and examine existing conditions which may affect work of this Division.

.2 Examine all Contract Documents to ensure that work of this Division may be satisfactorily completed.

.3 Notify Consultant upon discovery of conditions which adversely affect work of this division. No allowance will be made after letting of contract for any expenses incurred through failure to do so.

.4 Submission of a bid confirms that the Contract Documents and site conditions are accepted without qualifications, unless exceptions are specifically noted in the Bid.

1.8 Warranty

.1 Refer to General Conditions and Section 01 78 37 - Extended Warranties. Arrange with each manufacturer/supplier to extend warranties as necessary to coincide with warranty period or those periods specified.

.2 Make submissions necessary to register product warranties to the benefit of the Owner.

1.9 Definitions

.1 The following are definitions of words found in this specification and on associated drawings under this Division:

.1 "Concealed" - hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.

.2 "Exposed" - mechanical work normally visible to building occupants.

.3 "Provide" - (and all tenses of "provide") - supply, install and connect complete.

.4 "Install" - (and all tenses of 'install") - install and connect complete, products and services specified.

.5 "Supply" - supply to site in location determined by Owner.

.6 "Wet" - wet areas requiring special materials.

.7 “Finished Area” – means any area or part of an area which receives a finish such as paint or is factory finished.

.2 Wherever the words “indicated”, “shown”, “noted”, “listed”, or similar words or phrases are used in the Specification they are understood, unless otherwise defined, to mean that the product referred to as “indicated”, “shown”, “listed”, or “noted” on the Drawings.

.3 Wherever the words “approved”, “satisfactory”, “as directed”, “submit”, “permitted”, “inspected” or similar words or phrases are used in the Specification they are understood, unless otherwise defined, to mean that Work or product referred to as “approved by”, “inspected by”, etc., the Consultant

1.10 Interruptions

.1 Arrange execution of work to maintain present building operations, and to minimize the effect of work under this Division on existing operations.

.2 Upon award of the contract, submit a list of anticipated interruption times and their maximum duration.

.3 Prior to interrupting any existing service notify the Owner and Consultant, in writing, at least seventy two (72) hours in advance, and obtain written authorization. Do not interrupt any existing service without the Owner’s and/or Consultant's specific authorization.

.4 Arrange time and duration of interruption(s) through the Owner's representative(s). Include in Bid Price for all overtime or premium time hours necessary to minimize duration of service interruption.

.5 Test and verify the proper operation of existing equipment and systems that are shut down due to work of this project, prior to returning to service.

.6 Assume responsibility for consequential costs on failure to obtain permission to shut-down and/or start-up any item of equipment, system or service.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials and equipment

.1 Ensure materials and equipment provided under this Division are new and free from defects and bear labels of approval as required by codes referred to in this Division and/or by inspection authorities.

.2 Ensure apparatus and equipment provided under this Division bears manufacturer's nameplate indicating name of manufacturer, model number or type, size, capacity, CRN, and other pertinent information. Ensure nameplates are easily read and clearly visible, with openings provided where equipment is insulated.

.3 Ensure manufacturers and suppliers of equipment or materials under this Division determine if their products are composed of any hazardous materials. If they are, the products are suitably labelled and supplied with Material Safety Data sheets. Obtain the Owner's approval in writing to bring hazardous materials onto the site prior to doing so.

.4 When utilizing any products that are hazardous, keep Material Safety Data sheets on file at the job site and present them to anyone requesting this information. When transferring hazardous materials from original container into other containers, provide Workplace Labels on such containers.

2.3 Acceptable products

.1 First item named or specified by catalogue number meets specifications regarding performance, quality of material and workmanship, and is acceptable to the Consultant.

.2 Items, other than first named, meeting specifications regarding quality of materials and workmanship are acceptable to the Consultant, only, if they also meet performance and/or capacities specified and can be accommodated within the space allotted.

.3 General approval indicated by inclusion of other manufacturers named is subject to final review of shop drawings, performance data and test reports. It is understood that any additional costs, and changes to associated or adjacent work resulting from provision of products supplied by a manufacturer other than the first named is included in the tender price.

2.4 Substitutions

.1 In accordance with Section 01 25 00 - Substitution Procedures.

3 Execution

3.1 Relationship with other trades

.1 Cooperate with other trades whose work affects or is affected by work of this Division to ensure satisfactory installation and to avoid delays.

.2 Provide materials to be built-in, such as sleeves, anchors, and inserts, together with templates and/or measurements, promptly when required by other trades.

.3 Provide structural supports for equipment to be mounted on or in walls, supported above floors and/or suspended from the structure.

3.2 Installation requirements

.1 Install equipment neatly to the satisfaction of the Consultant. Unless noted otherwise install products and services to follow building planes. Ensure installation permits free use of space and maximum headroom.

.2 Confirm the exact location of outlets, fixtures and connections. Confirm location of outlets for equipment supplied under other Divisions.

.3 Install equipment and apparatus to allow free access for maintenance, adjustment and eventual replacement.

.4 Install metering and/or sensing devices to provide proper and reliable sampling of quantities being measured. Install instruments to permit easy observation.

.5 Provide suitable shielding and physical protection for devices.

.6 Install products and services in accordance with the manufacturer's requirements and/or recommendations.

.7 Provide bases, supports, hangers and fasteners. Secure products and services so as not to impose undue stresses on the structure and systems.

.8 Do not use powder activated tools without written permission of the Consultant. Use them in accordance with the Owner's health and safety policies.

.9 Ensure that the load onto structures does not exceed the maximum loading indicated on the structural drawings or as directed by the Consultant.

3.3 Contract drawings

.1 The drawings of this Division are performance drawings and indicate general arrangement of the work. They are diagrammatic except where specific details are given.

.2 Obtain accurate dimensions from the architectural and structural drawings, or by field measurement. Location and elevation of services are approximate. Verify them before construction is undertaken.

.3 Make changes, where required to accommodate structural conditions. Obtain Consultant's approval before proceeding.

.4 Adjust the location of materials and/or equipment as directed without adjustment to contract price, provided that the changes are requested before installation and do not affect material quantity. Outlets and/or equipment may be relocated up to 10 feet (3 m) in any direction without a change to the contract price.

.5 Note that the layout and orientation of the ceiling outlets on the architectural reflected ceiling plan drawings may differ from that shown on the mechanical drawings. Make the installation in accordance with the

latest architectural reflected ceiling plans. Provide the equipment as specified and/or shown on the documents of this Division.

.6 The drawings of this Division are intended for tender pricing. The quantities and quality to be included in the bid price shall be based on the layout and specifications as indicated in the mechanical documents. If there is a difference in quantity between the architectural and drawings of this Division, base the contract price on the greater quantity.

.7 Prepare installation drawings to reflect the latest architectural ceiling layout.

3.4 As-bult and Record drawings

.1 Refer to Section 01 78 00 – Closeout Submittals.

3.5 Special tools & spare parts

.1 Refer to Section 01 78 00 – Closeout Submittals and as specified in this section.

.2 On completion of the project furnish spare parts to the Owner as follows and as indicated in each section of these specifications:

.1 One (1) glass for each gauge glass installed.

.2 One (1) set of v-belts for each piece of equipment.

.3 One (1) set of new filters for each filter bank installed.

.3 Identify spare parts containers as to contents and replacement parts number.

.4 Provide one (1) set of special tools required to service equipment as recommended by manufacturers.

.5 Furnish one grease gun and adaptors to suit different types of grease and fittings.

3.6 Demonstration and Training

.1 Refer to Section 01 79 00 - Demonstration and Training and as specified in this section.

.2 Instruct and familiarize the Owner's operating personnel with the various mechanical systems. Arrange instruction for each system separately.

.3 Provide instruction for each system on two (2) separate occasions, coordinated with the Owner's staff operating schedule, in order that interested personnel may arrange to attend.

.4 Ensure each instruction period includes, but is not limited to the following;

.1 Classroom seminar with operating manuals, product and system drawings and such other audio/visual aids as may be appropriate,

.2 Instruction during the classroom seminar by the manufacturer's representative regarding the proper operating and maintenance procedures for each item of equipment,

.3 Demonstration of the proper operating procedures for each item of equipment,

.4 Explanation of the purpose and function of all safety devices provided, and

.5 Demonstration of all measures required for safe and proper access for operation and maintenance.

.5 Provide a period of follow-up instruction approximately one (1) month after completing the Owner's instruction to clarify and reinforce earlier instructions.

.6 Submit a letter from the Owner's management staff indicating the instruction has been given satisfactorily to the Consultant prior to substantial completion of the project.

3.7 Commissioning

.1 Refer to Section 01 91 00 – General Commissioning Requirements.

End of section

1 General

1.1 Section includes

.1 Section 20 05 00 applies to and governs all work of Division 20, 22 23, and 25.

1.2 References

.1 Provide all work in accordance with requirements of Regulatory Agencies and conform to:

.1 Local and district by-laws, regulations and published engineering standards.

.2 The Ontario Building Code as amended,

.3 The Ontario Gas Utilization Code as amended.

.4 Regulations for Construction Projects under The Occupational Health and Safety Act.

.5 Fire Code made under the Fire Marshal's Act.

.2 Conform to following CSA Standards:

.1 CSA B242 Groove and Shoulder Type: Mechanical Pipe Couplings.

.2 CSA B139 Installation Code for Oil-burning Equipment.

.3 CSA B64.10 Selection and Installation of Backflow Prevention Devices.

.4 CSA B64.10.1 Maintenance and Field Testing of Backflow Prevention Devices.

.3 Conform to following National Research Council Canada publications:

.1 National Building Code of Canada and Supplements to National Building Code of Canada

.2 National Fire Code of Canada.

.3 National Plumbing Code of Canada.

.4 The above documents or portions thereof are referenced within the work of Division 20, 22 23, and 25 and shall be considered part of the requirements of this document as though fully repeated herein.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Unions, flanges and dielectric couplings

.1 Cast brass, pressure, copper to copper unions shall be used with seamless copper tubing smaller than 3 in. (75 mm).

.2 Cast brass flanges shall be used with seamless copper tubing, type L for tubing 3 in. (75 mm) and larger.

.3 Dart type, 125 lb. (860 kPa) black malleable iron unions shall be used with all steel pipe for piping 2 ½ in. (65 mm) and smaller.

.4 Slip-on, 150 lb. (1,000 kPa) carbon steel flanges with 1/16 in. (4 mm) raised face shall be used with all steel pipe for piping larger than 2 ½ in. (65 mm).

.5 Gaskets for joining flanged steel pipe shall be 1/16 in. (4 mm) Cranite ring type gaskets.

.6 Install approved dielectric coupling insulation at transition between dissimilar materials such as copper, brass, bronze, high alloy castings or stainless steel and low alloy ferrous materials such as black iron, steel, galvanized iron, or cast iron.

.7 Piping specialties including backflow preventers, strainers, valves etc. shall be line size unless indicated otherwise on drawings.

2.3 Adhesives, sealants, paints and coatings

.1 Adhesives, Sealants, Paints and Coatings: Use only low VOC emitting materials in accordance with Section 01 81 13 – Sustainable Design Criteria.

3 Execution

3.1 Inspection

.1 Inspect installed work of other trades and verify that such work is complete to point where work under this Division may properly commence.

.2 Verify that work of this Division may be executed in accordance with pertinent codes and regulations, specifications, drawings, and referenced standards.

.3 Review drawings and verify dimensions at the site. Report discrepancies immediately to Consultant before proceeding with any construction work or shop drawings.

3.2 Preparation

.1 Existing services and equipment shall be relocated or removed to suit new construction and renovation work.

.2 Services that are no longer required shall be removed or cut back and capped to the satisfaction of Consultant.

.3 Obtain written authorization from Consultant for renovation work that is not specifically indicated.

.4 Where modifications or connections to existing systems require shutdown of the system the Contractor shall submit a request for system shutdown describing the system or part to be shutdown, the duration of the shutdown, the work planned and steps to be taken to reinstate the system to full operation. The request shall be submitted in the format stipulated by the Owner.

.5 All work required to prepare systems for shutdown and/or re-instatement, such as draining, chemical treatments, and re-filling shall be included in this Bid Price.

3.3 Above ground piping installation

.1 Cooperate with other trades whose work affects or is affected by work of this Section, to ensure satisfactory installation and to avoid delays. Provide all materials to be built-in such as sleeves, anchors, etc., together with accurate dimensions or templates, promptly.

.2 Layout all work accurately, installing piping parallel to lines of building.

.3 Install piping, wherever possible, in partitions and above ceiling. Do not install piping in outside walls unless so shown on drawings. Wrap un-insulated piping in masonry walls with building paper.

.4 Install concealed piping close to building structure to minimize furring dimensions.

.5 Provide adequate space around piping to facilitate application of thermal insulation.

.6 Use dielectric couplings where piping of dissimilar metals connect.

.7 Where piping passes through concrete floors, or walls, sleeves shall be sized to permit the pipe to expand freely without binding or crushing pipe insulation.

.8 Where branch pipes are welded into main without the use of "T" connections, torch cut openings must be cut true, bevelled and filed smooth. Branch pipes must not be allowed to project inside of main pipe. Openings must not be cut large enough to permit entry of welding metal and slag within the pipe.

.9 Arrange all take-offs from mains to allow for expansion and contraction of pipes. Hot water branches serving down feed risers must be taken from lower sides or bottom of mains and grade down slightly to risers. Branches which serve units above the mains shall be taken from the top or sides of mains.

.10 Install automatic control valves and wells supplied under other Sections of this Division.

3.4 Piping joints

.1 Make joints in piping installed under this Division using persons familiar with the particular materials being used and in accordance with Canadian Plumbing Code, manufacturer's instructions, and as specified herein.

.2 Use only welding and/or brazing operators, with a valid identification card, as issued under The Boiler and Pressure Vessels Act, to make joints in Registered Piping Systems, as indicated under Section 20 01 00 – Mechanical General Requirements.

.3 Use 95/5 Sb.Sn (tin-antimony) solder for joining copper drainage tubing smaller than 4 in. (100 mm), and for joining copper water tubing installed above grade, and smaller than 4 in. (100 mm).

.4 Use silver solder or Silfos for joining copper water tubing installed below grade, and all copper tubing 4 in. (100 mm) and larger in size.

.5 Carefully ream joints in threaded pipe and paint with approved graphite type joint sealer on male connections only. Make connections with proper wrench to suit pipe size. Where leaks occur, the joint shall be disassembled and corrected if possible, or replaced. Over-tightening, caulking or peening will not be acceptable.

.6 Make joints in cast iron pipe with standard M-J joints in accordance with manufacturer's recommendations and CSA B70-M86.

.7 Install unions or welding flanges at connections to valves, etc. to facilitate removal.

.8 Use butt welding and/or schedule 40 carbon steel welding fittings to join sections of steel piping with welding ends.

3.5 Flushing and cleaning

.1 Flush and sterilize domestic water mains in accordance with procedures established by AWWA Specification C601.

.2 Flush new domestic water piping in accordance with Local and Provincial Codes.

.3 Thoroughly flush all other piping installed by this Division.

.4 Remove, clean and replace all strainers in systems after flushing.

.5 Thoroughly clean all equipment and fixtures, lubricate mechanical equipment, and leave all items in perfect order ready for operation.

3.6 Piping systems testing and inspection

.1 Prior to tests, isolate all equipment or other parts which are not designed to withstand test pressures.

.2 Test all piping at the completion of roughing-in, before connecting to existing systems, and prior to concealment, insulation or covering of piping.

.3 Make tests, which are required by any authority having jurisdiction, in the presence of the authority's authorized inspector and shall be certified by them.

.4 Conduct tests in the presence of:

.1 Authorized inspector(s) for authorities having jurisdiction.

.2 The Owner's Representative

.3 The Consultant

.5 Notification must be given at least forty eight (48) hours in advance of tests being conducted, to all persons required to be present.

.6 Repair all leaks exposed during testing and retest. If defects in pipe or fittings are discovered in the system, they shall be removed and replaced.

.7 Certify tests: not required by authorities having jurisdiction.

3.7 Equipment testing and inspection

.1 Test operation of equipment installed under this Division according to instructions in appropriate articles of this Division. Make any required adjustments or replacements to ensure equipment is operating as intended. Retest equipment requiring adjustment or replacement.

.2 Pay all fuel consumption charges for equipment under testing and during commissioning.

.3 Conduct tests before application of external thermal insulation and before concealment of piping or ductwork.

.4 Arrange and pay for inspections by authorities as required by code and complete any changes or alterations required by such inspections.

.5 Conduct tests in the presence of:

.1 Authorized inspector(s) for authorities having jurisdiction.

.2 The Systems Verification Agency.

.3 The Consultant.

.4 The Owner's Representative.

.6 Notification must be given at least 48hours in advance of tests being conducted, to all persons required to be present.

3.8 Testing and balancing

.1 Allow sufficient time for testing and verification prior to substantial completion. Notify Testing and Balancing Agency on completion of adjusting and balancing of systems.

.2 Adjust systems and components (drives, sheaves, belts, etc.) as required by Testing and Balancing Agency.

.3 Maintain systems in full operation during testing and verification.

.4 Make adjustments to control systems as required, to facilitate verification. Maintain all safety controls in operation.

.5 Check and correct alignment of V-belts, drive shaft coupling drives, etc. as required by Testing and Balancing Agency.

.6 Provide pitot tube test fittings at all main branches of sheet metal work and at intake and discharge locations of air handling systems as required by Testing and Balancing Agency.

3.9 Electrical components and wiring

.1 Conform to requirements of Division 26, 27 and 28 for all wiring included in Division 20, 21, 22 23 and 25. Includes pre-wired equipment provided by Sections under Division 20, 21, 22 23 and 25.

.2 Ensure that all pre-wired electrical equipment is CSA approved. Arrange and pay for special approval where this is not possible.

.3 Coordinate all wiring requirements with other Divisions. Line voltage wiring from power distribution panels to starters and from starters to motors will be provided under Division 26. All the field wiring for equipment

shall be included under Division 20, 21, 22 23 and 25, unless specifically called for under Division 26.

3.10 Cutting and patching

.1 Include cutting and patching as required in execution of work under respective Sections of this Division.

.2 Holes through the structure will not be permitted without written approval of the Consultant. Any and all openings required through the completed structure must be clearly and accurately shown on a copy of the relevant structural drawing(s). Exact locations, elevations and size of the proposed opening must be identified well in advance of the need for the work.

.3 All sleeved or formed openings through the structure must be shown on sleeving drawings and must be approved by the Structural Consultant prior to construction.

.4 The Contractor shall conduct exploratory work including x-ray of the existing structure, shall mark the location of embedded reinforcements, anchors, conduits and piping on exposed surfaces of adjacent floors and/or walls and shall pay all associated costs.

.5 Reinforcing shall not be cut or modified without prior approval of the Structural Consultant. Should re-enforcement be cut without such prior approval, the cost of any additional re-enforcement deemed necessary by the Structural Consultant shall be the responsibility of this Contractor.

.6 Alternative imaging techniques are subject to the approval of the Structural Consultant.

.7 Ensure that cutting and patching of roofs and reinforced concrete structures is executed by specialists familiar with the materials affected, and is performed in a manner to neither damage nor endanger the work. Coordinate and supervise such cutting and patching.

.8 Maintain the integrity of fire rated assemblies where they are pierced by ducts and pipes.

.9 Make good surfaces affected by this work and repair finish to satisfaction of Consultant. Finish painting, where required, will be provided under Division 09.

.10 Stop work immediately upon discovery of any hazardous material and report discovery to the Owner and Consultant. Obtain instruction prior to proceeding with the work.

3.11 Excavating and backfilling

.1 Be responsible for excavation and backfilling necessary for installation of underground work under this Division.

.2 Excavate to the depth and dimensions shown on drawings.

.3 Keep excavation free of water by bailing, pumping or a system of drainage as required.

.4 Cut and trim banks of excavation evenly, as nearly vertical as possible, and shore if required to prevent caving-in.

.5 Keep bottom of excavation clean and clear of loose material. Slope or grade as required.

.6 Provide shoring in accordance with The Occupational Health and Safety Act, and Regulations for Construction Projects.

.7 Notify the Consultant immediately in case of encountering any unstable ground, unsuitable for bearing of pipes. Consultant will decide the method of installation of pipes in unstable ground.

.8 Inform the Consultant immediately if the excavation reveals seepage zones, springs or other unexpected sub-surface conditions which may necessitate revisions to drainage or water supply systems.

.9 Obtain Consultant's approval prior to commencement of backfilling of trenches. Backfill the trenches carefully to prevent injury to the work and subsequent settlement and execute backfilling generally as follows:

.1 provide minimum 6 in. (150 mm) fine gravel or coarse sand bedding (Class B) or as indicated for the bottom of trenches.

.2 Backfill above pipe bedding with granular material specified, hand tamp in layers of 6 in. (150 mm) thickness. Extend backfill 12 in. (300 mm) above pipe.

.3 Backfill and consolidate remainder of trench depth below paved or gravelled areas with granular Class "B" aggregate in 6 in. (150 mm)

layers to an elevation to allow for thickness of Class "A" aggregate and asphalt pavement.

.4 Backfill and consolidate reminder of trench depth below sodded or seeded areas with specified granular material or material obtained from site excavation where approved by Consultant, in 9 in. (225 mm) layers to an elevation 6 in. (150 mm) below of proposed grades in sodded/seeded areas.

.5 Compact each layer thoroughly at optimum moisture content with approved hand or mechanical tampers to a density equal to;

.1 95 % of Maximum Standard Proctor Density

.1 Behind foundation and retaining walls on grades

.2 Below sodded or seeded areas

.2 100 % of Maximum Standard Proctor Density

.1 Below slabs on grade within building areas up to the underside of the crushed stone underlay

.2 Below paved or gravelled areas

.6 Do not puddle or flood with water for consolidating backfill. Add water during the compaction to optimum moisture content of backfilling material.

3.12 Support and attachment

.1 Support and attach piping, ductwork fixtures and equipment from load bearing structures such as beams, joists, reinforced concrete slabs and concrete block walls, and do not support from or attach to steel roof deck and/or wall or ceiling finishes. Roof mounted mechanical equipment and services shall be anchored to the roof structure to resist both lateral and uplift wind forces in accordance with requirements of the Ontario Building Code.

3.13 Painting

.1 Repair minor damage to finish of equipment with standard factory applied baked enamel finish under the appropriate Sections. Replace entirely, items suffering major damage to finish if too extensive to be repaired in the opinion of the Consultant.

.2 Apply at least one coat of corrosion resistant primer paint to supports, and equipment fabricated from ferrous metals.

3.14 Dissimilar metals

.1 Separate dissimilar metals in order to prevent galvanic corrosion.

.2 Provide gaskets or shims of approved materials to avoid electrolytic action.

.3 Use dielectric unions and/or flanges where piping of dissimilar metals are connected.

3.15 Equipment bases and curbs

.1 Supply and erect structural work required for installation of mechanical equipment.

.2 Build concrete bases 4 in. (100 mm) high, providing all necessary inserts, anchor bolts and other fasteners required, for floor mounted tanks, heaters, pumps, air handlers, boilers, etc. Make concrete bases 2 in. (50 mm) larger all around than the base of the supported equipment and trowel finish to a neat smooth finish. Anchor equipment to pads using 8 in. (200 mm) cast-in-place anchor bolts. Ensure concrete supplied under this Division is 2,500 psi (17 MPa) compressive strength after twenty eight (28) days.

.3 Build 4 in. (100 mm) high concrete curbs around all openings through floors for ductwork. Make allowances for installation of ductwork and fire dampers where required. Ensure joint between curb and floor is watertight and maintains integrity of floor membrane where applicable.

3.16 Service connections

.1 Include in Bid Price all amounts required by municipality and/or utilities for service connections and /or modifications to service connections for water services. Ensure amounts include fees, assessments, charges, etc., required in relation to service connection. Do not include acreage or frontage charges.

3.17 Belt drives and sheaves

.1 Provide belt driven equipment with V-belt drive, designed for at least 130 % of motor nameplate horsepower rating and in accordance with manufacturer's recommendations for type of service intended. Ensure belt drives are at least 95 % efficient. Balance and properly align drives. Provide matched sets of belts for multiple belt assemblies. Select belts to suit starting torque of drive. Do not use single belt drives for motors larger than two horsepower.

.2 Provide motor sheaves for one and two belt drives of variable pitch type, with Dodge key adjustments. Supply two sets of fixed drive sheaves for drives with three or more belts. Install first set of fixed motor sheaves to obtain the originally specified RPM. After initial test and preliminary adjustment, supply and install the second set of fixed sheaves if necessary, to provide the design flow quantities as established on the job. Obtain correct total flow rate for fans through speed changes and not by throttling.

.3 Provide adjustable sheaves on motor sizes up to 2 HP (1,492 w) and fixed sheaves on larger motors.

3.18 Field quality control

.1 Temporary and Trial Usage

.1 Allow the Owner the privilege of temporary and trial usage of installed equipment, as soon as work is complete, for a period of time required to conduct a thorough test.

.2 Do not construe such usage as evidence of acceptance of work by Owner.

.3 Repair damage to work tested, resulting from such trial usage, by this Contractor at no cost to Owner.

.2 Systems Verification:

.1 Verify the correct installation and proper operation of equipment and systems installed. Adjust and balance each system as necessary to achieve optimum operation of each system.

.2 Co-operate with the Systems Verification agency as follows:

.1 Provide assistance when and as requested

.2 Co-ordinate completion of work systematically to permit orderly verification and adherence to schedules,

.3 Provide additional necessary flow balancing devices as directed by agency,

.4 Notify the Systems Verification Agency of tests being conducted.

3.19 Adjust and clean

.1 Clean equipment and fixtures, lubricate mechanical equipment installed under this Division and leave items in perfect order ready for operation.

.2 Test and adjust control devices, instrumentation, relief valves, dampers, etc., installed in this Division after cleaning of systems and leave in perfect order ready for operation.

.3 Remove from the premises upon completion of work of this division, debris, surplus, and waste materials resulting from operations.

End of section

MECHANICAL ELECTRICAL COORDINATION SCHEDULE

No.	Equipment				Controls			Responsibility		
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed by Div.	Wired and Connected by Div.
1	Fan Coil Unit [FC-1]	MCA	2.2	Sim Lab [114]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
2	Fan Coil Unit [FC-2]	MCA	4.7	Gender Neutral W/R [128]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
3	Fan Coil Unit [FC-3]	MCA	2.9	Report Writing [103]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
4	Fan Coil Unit [FC-4]	MCA	5.8	Kitchen [104]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
5	Fan Coil Unit [FC-5]	MCA	8.5	Corridor [102]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
6	Fan Coil Unit [FC-6]	MCA	2.2	Medical Storage [127]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
7	Fan Coil Unit [FC-7]	MCA	8.5	Kitchen [121]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
8	Fan Coil Unit [FC-8] & [FC-19]	MCA	5.3	Open Office [108]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
9	Fan Coil Unit [FC-9]	MCA	2.2	Break-Out [109]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
10	Fan Coil Unit [FC-10]	MCA	5.8	Classroom [112]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
11	Fan Coil Unit [FC-11]	MCA	5.8	Classroom [113]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
12	Fan Coil Unit [FC-12]	MCA	8.5	Corridor [107]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							

MECHANICAL ELECTRICAL COORDINATION SCHEDULE

No.	Equipment				Controls			Responsibility		
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed by Div.	Wired and Connected by Div.
13	Fan Coil Unit [FC-13]	MCA	5.8	Lounge [105]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
14	Fan Coil Unit [FC-14] & [FC-18]	MCA	5.8	Open Office [204]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
15	Fan Coil Unit [FC-15]	MCA	8.5	Emergency Operations Center [202]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
16	Fan Coil Unit [FC-16]	MCA	8.5	Emergency Operations Center [203]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
17	Fan Coil Unit [FC-17]	MCA	2.2	Break-Out [205]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
18	Fan Coil Unit [FC-20]	MCA	8.0	Electrical Room [123]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
19	Forced Flow Heater [FF-1]	Amp	1.9	Vestibule [101]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
20	Forced Flow Heater [FF-3]	Amp	1.9	Vestibule [122]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
21	Forced Flow Heater [FF-4]	Amp	1.9	Gender Neutral W/R [117]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
22	Forced Flow Heater [FF-5]	Amp	1.9	Corridor [107]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
23	Forced Flow Heater [FF-6]	Amp	1.9	Vestibule [207]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
24	Unit Heater [UH-1]	Amp	2	Mechanical room [124]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							

MECHANICAL ELECTRICAL COORDINATION SCHEDULE

No.	Equipment				Controls			Responsibility		
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed by Div.	Wired and Connected by Div.
25	Dedicated Outdoor Air System [DOAS-1] Supply Fan	MCA	10.6	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	208		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60		Remote Control Panel			23	23	26
26	Dedicated Outdoor Air System [DOAS-1] Exhaust Fan	MCA	5.5	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	208		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60		Remote Control Panel			23	23	26
27	Dedicated Outdoor Air System [DOAS-1] Energy Recovery Wheel	FLA	2.4	Mechanical Room [124]	Disconnect	At Unit		26	26	26
		Voltage	208		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
28	Wall Mounted AC Indoor Unit [AC-1]	MCA	1	IT Room [125]	Disconnect	At Unit		26	26	26
		Voltage	208		Other Controls	BAS		25	25	25
		Phases	1		Other Controls	Thermostat		23	25	25
		Freq.	60		[CU-1] Condenser Interlock			26	26	26
29	Remote Air Cooled Condenser [CU-1]	MCA	19	Roof	Disconnect	At Unit		23	26	26
		Voltage	208		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
30	Heat Pump [HP-1]	MCA	58	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter					
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
31	Heat Pump [HP-2]	MCA	35	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter					
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
32	Electric Boiler [B-1]	kW	94	Mechanical Room [124]	Disconnect	At Unit		23	26	26
		Voltage	600		Comb. Starter					
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
33	Energy Recovery Ventilator [ERV-1] Supply Fan	MCA	4.3	Roof	Disconnect	At Unit		26	26	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
34	Energy Recovery Ventilator [ERV-1] Exhaust Fan	MCA	2.9	Roof	Disconnect	At Unit		26	26	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
35	Energy Recovery Ventilator [ERV-1] Energy Recovery Wheel	FLA	2.4	Roof	Disconnect	At Unit		26	26	26
		Voltage	208		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
36	Energy Recovery Ventilator [ERV-1] Lighting & Service Receptacle	MCA	2 x 15	Roof	Disconnect	At Panel		26	26	26
		Voltage	120		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60							

No.	Equipment				Controls			Responsibility		
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed by Div.	Wired and Connected by Div.
37	Geothermal Field Primary Pumps [P-1A] & [P-1B]	HP	5	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
38	HP-1 Secondary Pump [P-2]	HP	1.5	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
39	HP-2 Secondary Pump [P-3]	HP	3/4	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
40	Chilled Water Primary Pump [P-4A] & [P-4B]	HP	3/4	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
41	Heating Water Primary Pump [P-5A] & [P-5B]	HP	1	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
42	Chilled Water Secondary Pump [P-6A] & [P-6B]	HP	1.5	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
43	Heating Water Secondary Pump [P-7A] & [P-7B]	HP	1.5	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
44	Heating Glycol Secondary Pump [P-8]	HP	1/2	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	575		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
45	Boiler Injection Pump [P-9]	HP	1/6	Mechanical Room [124]	Disconnect	At Unit		23	23	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60							
46	Exhaust Fan [EF-1]	Watts	250	Mechanical Room [124]	Disconnect	At Unit		23	26	26
		Voltage	115		Other Controls	BAS		25	25	25
		Phases	1		Other Controls	Remote Thermostat		25	25	25
		Freq.	60		Interlocked with Intake Motorized Damper			25	25	25
47	Exhaust Fan [EF-2]	Watts	370	Electrical Room [123]	Disconnect	At Unit		23	26	26
		Voltage	115		Other Controls	BAS		25	25	25
		Phases	1		Other Controls	Remote Thermostat		25	25	25
		Freq.	60		Interlocked with Intake Motorized Damper			25	25	25
48	Exhaust Fan [EF-3]	Watts	55	Universal W/R [119]	Disconnect	Plug-in		23	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	Interlocked with lighting		26	26	26
		Freq.	60		Speed Controller (Unit Mounted)			23	26	26

MECHANICAL ELECTRICAL COORDINATION SCHEDULE

No.	Equipment				Controls			Responsibility		
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed by Div.	Wired and Connected by Div.
49	Exhaust Fan [EF-4]	Watts	80	Decon. Shower [130]	Disconnect	Plug-in		23	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	Interlocked with lighting		26	26	26
		Freq.	60		Speed Controller (Unit Mounted)			23	26	26
50	Exhaust Fan [EF-5]	Watts	55	Linen Room [134]	Disconnect	Plug-in		23	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60		Speed Controller (Wall Mounted)			23	23	26
51	Exhaust Fan [EF-6]	Watts	55	Storage Room [116]	Disconnect	Plug-in		23	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	Interlocked with lighting		26	26	26
		Freq.	60		Speed Controller (Wall Mounted)			23	23	26
52	Exhaust Fan [EF-7]	Watts	55	Janitor Room [120]	Disconnect	Plug-in		23	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls	Interlocked with lighting		26	26	26
		Freq.	60		Speed Controller (Unit Mounted)			23	26	26
53	Exhaust Fan [EF-8]	Watts	55	Medical Storage Room [127]	Disconnect	Plug-in		23	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60		Speed Controller (Wall Mounted)			23	23	26
54	De-Stratification Fan [DF-1] & [DF-2]	MCA	10	Vehicle Bay [131]	Disconnect	At Unit		26	26	26
		Voltage	208		Comb. Starter	VFD		23	23	26
		Phases	3		Other Controls	SmartSense		23	25	25
		Freq.	60		BAS			25	25	25
55	Kitchen Hood [KH-1] & [KH-2]	Amp.	1.4	Kitchen [121] & [104]	Disconnect	At Panel		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60		Speed Controller			23	26	26
56	Humidifier [HU-1]	FLA	15	Mechanical Room [124]	Disconnect	At Unit		26	26	26
		Voltage	600		Comb. Starter					
		Phases	3		Other Controls					
		Freq.	60		Remote Humidistat			25	25	25
57	Glycol Fill System [G-1]	HP	3/4	Mechanical Room [124]	Disconnect	At Unit		26	26	26
		Voltage	115		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60							
58	Domestic Water Heaters [EWH-1] & [EWH-2]	kW	18	Mechanical Room [124]	Disconnect	At Panel		26	26	26
		Voltage	208		Overcurrent Protection			26	26	26
		Phases	3		Other Controls	BAS		25	25	25
		Freq.	60							
59	Domestic Hot Water Recirculation Pump [P-10]	Watts	60	Mechanical Room [124]	Disconnect	At Unit		26	26	26
		Voltage	120		Comb. Starter					
		Phases	1		Other Controls	BAS		25	25	25
		Freq.	60		Aquastat and Timer			22	22	26
60	Electronic Trap Seal Primers [TSP]	Watts	6	Various (See Plans)	Disconnect	At Panel		26	26	26
		Voltage	120		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60							

No.	Equipment				Controls			Responsibility		
	Item	Characteristics		Location	Type	Location	Manufacturer's Reference	Supplied by Div.	Installed by Div.	Wired and Connected by Div.
61	Snow Melt System Coontrol Panel 1 [SM-1]	kW	33	Mechanical Room [124]	Disconnect	At Panel		26	26	26
		Voltage	208							
		Phases	3		In-Slab Cables			23	26	26
		Freq.	60		Cabling to In-Slab Cables			26	26	26
62	Snow Melt System Control Panel 2 [SM-2]	kW	27.4	Mechanical Room [124]	Disconnect	At Panel		26	26	26
		Voltage	208							
		Phases	3		In-Slab Cables			23	26	26
		Freq.	60		Cabling to In-Slab Cables			26	26	26
63	HVAC Chemical Treatment System [CT-1], [CT-2], [CT-3] and [CT-4]			Mechanical Room [124]	Disconnect	Plug-in		23	26	26
		Voltage	120		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60							
64	Water Softener [WS-1] & [WS-2]	Amp.	0.5	Mechanical Room [124]	Disconnect	Plug-in		23	26	26
		Voltage	120		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60							
65	Building Automation System Control Panels [BAS] 1&2			IT Room [125]	Disconnect	At Panel		26	26	26
		Voltage	120		Comb. Starter					
		Phases	1		Other Controls					
		Freq.	60							

1 General

1.1 Section includes

.1 Variable Frequency Drives (VFD's).

1.2 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.

.4 Manufacturer's Installation Instructions: indicate setting, mechanical connections, lubrication, and wiring instructions.

.5 Submit manufacturer's performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD's full load amperage (FLA) rating, certification agency file numbers and catalogue information.

.6 The specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from this specification are identified, the supplier shall be bound by the specification.

.7 Harmonic filtering: The vendor shall, with the aid of the buyer's electrical power single line diagram, providing the data required by IEEE-519, perform an analysis to initially demonstrate the supplied equipment will met the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2 and 10.3 at the point of

common coupling (PCC). The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformer.

1.3 Quality assurance

.1 Conform to Ontario Electrical Safety Code.

.2 Provide certificate of compliance from authority having jurisdiction indicating approval of variable frequency drives.

.3 All optional features shall be functionally tested at the factory for proper operation.

1.4 Regulatory requirements

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

1.5 Delivery, storage and protection

.1 Protect variable frequency drives stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering.

1.6 Warranty

.1 Provide extended coverage five (5) year warranty starting from date of Substantial Performance for variable frequency drives.

.2 The warranty shall include parts, labour, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Manufacturer

.1 Provide Danfoss VLT FC102 Variable Frequency Drives; or

.2 Approved alternates, subject to shop drawing review.

.1 ABB;

.2 Eaton / Cutler Hammer; or

.3 Other approved alternate.

2.3 Variable frequency drives

.1 Furnish complete VFDs as specified herein for the fans and pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD's shall be housed in a metal NEMA enclosures rated for the environment the drive shall be located. The VFD's UL listing shall allow mounting in plenum or other air handling compartments. The drive efficiency shall be 96 % or better at full speed and load.

.2 The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor de-rating.

.3 With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFD's utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

.4 The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.

.5 The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate CSA or C-UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.

.6 The VFD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFDs without DC link reactors shall provide a minimum 3 % impedance line reactor.

.7 The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110 % of rated current for sixty (60) seconds and 160 % of rated current for up to 0.5 second while starting.

.8 The VFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without de-rating.

.9 An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.

.10 Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to one (1) time per minute on the input and unlimited on the output.

.11 An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.

.12 Galvanic and/or optical isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analogue I/O and discrete I/O shall include additional isolation modules.

.13 VFD power components to be designed for 575 VAC. Components designed for 480 VAC are not acceptable.

.14 VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.

.15 VFD's operating motors not designed to meet NEMA MG1 Part 31 should include Output Load reactors.

2.4 Protective features

.1 A minimum of Class 20 I^2t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.

.2 Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over-voltage, under-voltage, VFD over-temperature and motor over-temperature. The VFD shall display all faults in plain English. Codes are not acceptable.

.3 Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90 % of the nominal.

.4 The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.

.5 To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Motors shall have inverter rated insulation (1,600 V).

.6 VFD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10V DC, and shall be programmable to react as desired in such an instance.

.7 VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.

.8 VFD shall catch a rotating motor operating forward or reverse up to full speed.

.9 VFD shall be rated for 100,000 amp interrupting capacity (AIC).

.10 VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.

.11 VFD shall continue to operate without faulting until input voltage reaches 300 VAC on 208/230 volt VFDs, 539 VAC on 460 volt VFDs, and 701 VAC on 575 volt VFDs.

2.5 Interface features

.1 Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.

.2 The VFD shall be able to be programmed to provide a 24 VDC output signal to indicate that the VFD is in Auto/Remote mode.

.3 The VFD shall provide digital manual speed control. Potentiometers are not acceptable.

.4 Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 ft. (3m) away using standard nine (9) pin cable.

.5 The keypads for all sizes of VFDs shall be identical and interchangeable.

.6 To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFD’s in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.

.7 Display shall be programmable to display in nine (9) languages including English, Spanish and French.

.8 The display shall have four (4) lines, with twenty (20) characters on three (3) lines and eight (8) large characters on one line.

.9 A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

.10 A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.

.11 The VFD shall include a standard RS-485 communications port and capabilities to be connected at a future date to a Johnson Controls N2, Siemens FLN, Lonworks, or approved alternate. The connection shall be software selectable by the user.

.12 As a minimum, the following points shall be controlled and/or accessible:

.1 VFD Start/Stop, Speed reference, Fault diagnostics, and Meter points as follows;

.2 Motor power in HP, Motor power in kW, Motor kW-hr, Motor current, Motor voltage, Hours run, Feedback signal #1, Feedback signal #2, DC link voltage, Thermal load on motor, and Thermal load on VFD, heat sink temperature.

.13 Four additional Form C 230 volt programmable relays shall be available for factory or field installation within the VFD.

.14 Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.

.15 Floating point control interface shall be provided to increase/decrease speed in response to contact closures.

.16 Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFDs unable to show these four displays simultaneously shall provide panel meters.

.17 Sleep mode shall be provided to automatically stop the VFD when its speed drops below set "sleep" level for a specified time. The VFD shall automatically restart when the speed command exceeds the set "wake" level.

.18 The sleep mode shall be functional in both follower mode and PID mode.

.19 Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.

.20 The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.

.21 The display shall be programmed to read in pascals (Pa) for an air handler application, kilopascals (kPa) for a pump application, and temperature Celsuis (°C) for a cooling tower application.

.22 VFD's shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.

.23 If the temperature of the VFD's heat sink rises to 176 °F (80 °C), the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.

.24 The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.

.25 The VFD shall store in memory the last ten (10) faults and related operational data.

.26 Eight (8) programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.

.27 Two programmable relay outputs, one Form C 240 VAC, one Form A 30 VAC, shall be provided for remote indication of VFD status.

.28 Three (3) programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 VDC, 2 to 10 VDC) and one current (0 to 20 mA, 4 to 20 mA) input.

.29 Two (2) programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 VDC status indication.

.30 Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.

2.6 Adjustments

.1 VFD shall have an adjustable carrier frequency in steps of not less than 0.1kHz to allow tuning the VFD to the motor.

.2 Sixteen (16) preset speeds shall be provided.

.3 Four (4) acceleration and four (4) deceleration ramps shall be provided. Acceleration and deceleration time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.

.4 Four (4) current limit settings shall be provided.

.5 If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: under voltage, overvoltage, current limit and inverter overload.

.6 The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.

.7 An automatic "on delay" may be selected from 0 to 120 seconds.

2.7 Bypass

.1 Provide a manual 3-contactor bypass, were indicated in schedules, consisting of a door interlocked main fused disconnect pad lockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode.

.2 Service personnel shall be able to defeat the main power disconnect and open the bypass enclosure without disconnecting power. This shall be

accomplished through the use of a specially designed tool and mechanism while meeting all local and national code requirements for safety.

2.8 Service conditions

.1 Ambient temperature, 14 °F to 104 °F (-10 °C to 40 °C).

.2 0 to 95 % relative humidity, non-condensing.

.3 Elevation to 3,300 ft. (1,006 m) without de-rating.

.4 AC line voltage variation, -10 to +10 % of nominal with full output.

.5 No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

3 Execution

3.1 Start up service

.1 The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.

3.2 Examination

.1 Contractor to verify that job site conditions for installation, meet factory recommended and code required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendations shall be verified.

.2 The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

End of section

1 General

1.1 Section includes

.1 Flexible pipe connectors

.2 Expansion joints and compensators

.3 Pipe loops, offsets, and swing joints

.4 Anchors and guides.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

.2 Read and conform to:

.1 The Contract CCDC 2, Stipulated Price Contract as amended in the Contract Documents;

.2 Division 01 requirements and documents referred to therein.

1.3 References

.1 Refer to the latest edition of the following:

.1 CSA B51 Boiler, Pressure Vessel and Pressure Piping Code

.2 ASME B31.1 Code for Power Piping

.3 ASME B31.3 Process piping

.4 MIL-E-17814E - Expansion Joints, Pipe, Slip-Type, Packed

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data:

.1 Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per metre and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.

.2 Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.

.4 Design Data: Submit shop drawings for expansion compensation, signed and sealed by a professional engineer licensed where the work is to be performed (i.e. Province of Ontario). Provide selection criteria used.

.5 Manufacturer's Installation Instructions: Indicate special procedures, and external controls.

1.5 Quality assurance

.1 Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three (3) years documented experience.

.2 Design expansion compensating system under direct supervision of a Professional Engineer experienced in the design of this work and licensed where the work is to be performed.

1.6 Delivery, storage and protection

.1 Accept expansion joints on site in factory packing with shipping bars and positioning devices intact. Inspect for damage.

.2 Protect equipment from exposure by leaving factory coverings, pipe end protection, and packaging in place until installation.

1.7 Warranty

.1 Warranty: Five (5) year replacement warranty, starting from date of Substantial Performance.

1.8 Extra materials

.1 Provide two (2) 0.77 oz (340 gm) containers of packing lubricant and cartridge style grease gun.

1.9 Performance requirements

.1 Provide structural work and equipment required to control expansion and contraction of piping.

.2 Verify that anchors, guides, and expansion joints provided will adequately protect the system for which they are installed.

.3 Arrange all piping so that expansion and contraction of any piping may take place without placing undue strain on the piping or connections to the equipment. Use swing joints and suitable expansion joints wherever necessary due to field conditions and where indicated on the drawings.

.4 This Section shall analyze each section of pipe installed between constraints and shall determine the potential for expansion of the pipe based on pipe temperature at installation and pipe temperatures throughout the pipe's operating range. Where potential expansion exceeds 1" (25mm) over the length of the pipe section, expansion compensators shall be installed. Pipe sections are constrained where they penetrate walls, partitions, floors, ceilings, roofs and movement of the pipe is restricted and where the pipe is anchored to the building structure.

.5 Expansion Calculations:

.1 Safety Factory: 30 %.

.2 Installation Temperature: 50 °F (10 °C).

.3 Hot Water Heating: 180 °F (82 °C).

.4 Domestic Hot Water: 140 °F (60 °C).

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Manufacturers

.1 Manufacturers must be certified by the Expansion Joint Manufacturers Association (EJMA)

.2 Flexible Pipe Connectors

.1 Flex-Pression Ltd.;

.2 Senior Flexonics Canada;

.3 Ontario Hose Specialties Ltd.;

.4 Colton Industries; or

.5 Approved alternate.

.3 Expansion Joints

.1 Flex-Pression Ltd.;

.2 Hyspan Precision Products, Inc.;

.3 Senior Flexonics Canada; or

.4 Approved alternate.

.4 Pipe Alignment Guides

.1 Flex-Pression Ltd.;

.2 Hyspan Precision Products, Inc.;

.3 Senior Flexonics Canada; or

.4 Approved alternate.

.5 Alternates are subject to shop drawing review.

2.3 Pipe alignment guides

.1 Steel Pipe:

.1 Radial "spider" type, minimizing piping motions in non-axial planes.

.2 Constructed of carbon steel with a 360 ° two-piece bolted housing, and a 360 ° two-piece bolted clamps with spider type legs.

.3 Provide an insulation clearance of 1.5 in. (38 mm) on sizes 6 in. (150 mm) IPS and smaller, and 2.0 in. (50 mm) on sizes 8 in. (200 mm) IPS and over.

.4 Axial travel shall be 3 in. (75 mm) for sizes 2 in. (50mm) IPS and smaller, and 6 in. (150 mm) for sizes 2 ½ in. (65 mm) IPS and over.

.5 Refer to piping and expansion joint schedules for specific insulation and motion requirements.

.6 Basis of design: Hyspan Series 9500 or approved alternate.

.2 Copper Pipe:

.1 Radial "spider" type, minimizing piping motions in non-axial planes.

.2 Constructed of carbon steel with non-metallic coating on the tube clamps, and a 360 ° two-piece bolted housing, and 360 ° two-piece bolted clamps with spider type legs.

.3 Provide an insulation clearance of 1.5 in. (38 mm).

.4 Axial travel shall be 3 in. (75 mm) for sizes 2 ½ in. (65 mm) and smaller, or 6 in. (150 mm) for sizes 3 in. (75 mm) and larger.

.5 Refer to piping and expansion joint schedules for specific insulation and motion requirements.

.6 Basis of design: Hyspan Series 9500 or approved alternate.

2.4 Flexible pipe connectors

.1 Copper Piping:

.1 Inner Hose: Bronze

.2 Exterior Sleeve: Braided bronze.

.3 Pressure Rating: 125 psi (862 kPa) WSP and 450 °F (232 °C).

.4 Joint: As specified for pipe joints.

.5 Size: Use pipe sized units

.6 Maximum offset: ¾ in. (19 mm) on each side of installed centre line.

.2 Steel Piping: 2 in. (50 mm) diameter and smaller:

.1 Inner Hose: Braided bronze.

.2 Exterior Sleeve: None.

.3 Pressure Rating: 125 psi (862 kPa) WSP and 450 °F (232 °C).

.4 Joint: Threaded.

.5 Size: Use pipe sized units.

.6 Maximum offset: ¾ in. (19 mm) on each side of installed centre line.

.3 Steel Piping: 2 ½ in. to 3 in. (65 mm to 75 mm) diameter:

.1 Inner Hose: Braided bronze.

.2 Exterior Sleeve: None.

.3 Pressure Rating: 125 psi (862 kPa) WSP and 450 °F (232 °C).

.4 Joint: Flanged.

.5 Size: Use pipe sized units.

.6 Maximum offset: ¾ in. (19 mm) on each side of installed centre line.

.4 Steel Piping: 4 in. (100 mm) diameter and larger:

.1 Inner Hose: Braided 321 stainless steel.

.2 Exterior Sleeve: None.

.3 Pressure Rating: 125 psi (862 kPa) WSP and 450 °F (232 °C).

.4 Joint: Flanged.

.5 Size: Use pipe sized units.

.6 Maximum offset: ¾ in. (19 mm) on each side of installed centre line.

2.5 Expansion joints – copper piping

.1 Bronze Bellows Type:

.1 Construction: two (2) ply bronze with anti-torque device, limit stops, and internal guides.

.2 Pressure Rating: 125 psi (862 kPa) WSP and 400 °F (204 °C).

.3 Maximum Compression: 1 ¾ in. (45 mm).

.4 Maximum Extension: ¼ in. (6 mm).

.5 Joint: Soldered.

.6 Size: Use pipe line sized units.

2.6 Expansion joints – 150 PSIG (1,034 kPa) / 500 °F (260 °C)

.1 Ratings

.1 Design Pressure: 150 psig (1,035 kPa)

.2 Test Pressure: 225 psig (1,552 kPa)

.3 Design Temperature: 500 °F (260 °C)

.2 Stainless Steel Bellows Type:

.1 Construction multi-ply ASTM A240 type 321 stainless steel bellows, ASME A53, Gr. B carbon steel housing,

.2 Maximum Compression: 1 ¾ in. (45 mm).

.3 Maximum Extension: ¼ in. (6 mm).

.4 Joint: Flanged.

.5 Size: Use pipe line sized units

.6 Application: Steel piping 2 ½ in. (65 mm) and smaller.

2.7 Expansion joints – 300 PSIG (2,070 kPa) / 500 °F (260 °C)

.1 Ratings

.1 Test Pressure: 450 psig (3,105 kPa)

.2 Externally Pressurized:

.1 Construction: Self-equalizing type with three or four ply ASTM A240 type 321 stainless steel bellows; ASME A53, Grade B carbon steel housing and pipe nipples; ASME-A36 steel plate guide rings and flanges; ASME A105, 3000-lb thread-o-let drain port & plug.

.2 Pressure Rating: 300 psi (2,070 kPa) WOG and 500 °F (260 °C).

.3 Maximum Compression: 8 in. (200 mm).

.4 Maximum Extension: 2 in. (50 mm).

.5 Joints: Flanged.

.6 Size: Use pipe line sized units.

.7 Application: Steel piping 3 in. (75 mm) and larger.

3 Execution

3.1 Installation

.1 Install flexible pipe connectors and expansion joints to manufacturer's instructions.

.2 Ratings and bolt patterns for flanges shall suit design pressure and design temperature of piping system and match those of installed components.

.3 Construct spool pieces to exact size of flexible connection for future insertion.

.4 Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.

.5 Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.

.6 Pipe anchors shall be installed securing the piping system to the building structure in order to control the direction and the amount of pipe movement. In addition, pipe anchors shall be installed to prevent separation of pipe due to hydraulic pressures. Pipe anchors shall be designed by the Contractor to accommodate all forces experienced. Prepare calculations for each anchor and submit to Consultant for review and approval. Provide pipe guides so movement is directed along axis of pipe only. Not less than two (2) guides shall be provided on each side of an expansion joint. Erect piping such that strain and weight is not on cast connections or apparatus.

.7 Provide support and equipment required to control expansion and contraction of piping. Provide pipe offsets, and swing joints, or expansion joints where required. The Contractor may elect to install expansion loops in place of expansion compensators where there is adequate space to do so; subject to the approval of the Consultant. The Contractor shall prepare and submit detailed design calculations for each expansion loop proposed to the Consultant for review and approval prior to installation.

3.2 Manufacturer’s field services

.1 Provide inspection services by manufacturer's representative for final installation and certify installation is to manufacturer's recommendations and connectors are performing satisfactorily.

End of section

1 General

1.1 Section includes

.1 Thermometers.

.2 Pressure Gauges.

.3 Water Meters.

.4 Flow Measuring Stations.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 ASME B40.100 - Pressure Gauges and Gauge Attachments.

.2 ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi.

.3 ASTM E1 - Specification for ASTM Thermometers.

.4 ASTM E77 - Inspection and Verification of Thermometers.

.5 AWWA C700 - Cold Water Meters - Displacement Type, Bronze Main Case.

.6 AWWA C701 - Cold Water Meters - Turbine Type, for Customer Service.

.7 AWWA C702 - Cold Water Meters - Compound Type.

.8 AWWA C706 - Direct-Reading, Remote Registration System for Cold-Water Meters.

.9 AWWA M6 - Water Meters - Selection, Installation, Testing, and Maintenance.

.10 ISA RP 3.2 - Flange Mounted Sharp Edged Orifice Plates for Flow Measurement.

.11 UL 393 - Indicating Pressure Gauges for Fire-Protection Services.

.12 Refer to the latest edition of the above noted items.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Submit shop drawings in accordance with Section 20 01 00 – Mechanical General Requirements, for the following items:

.1 Thermometers,

.2 Pressure gauges,

.3 Water meters,

.4 Flow Measuring Stations.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Thermometers

.1 Thermometers for use in pipelines, shall be Trerice model BX9-1-403, or approved alternate, heavy duty industrial type with dual scale range (metric and imperial), adjustable angle separable sockets connections, cast aluminum case finished in dull black baked enamel, glass front with chrome plated frame, 225 mm (9 in.) long scale and red reading mercury. Range of scale, unless otherwise specified shall be from approximately 20 % below minimum to 20 % above maximum temperature encountered. Thermometers shall have extension necks and extended stems.

.2 Duct thermometers shall be Trerice model BX9-9-006, or approved alternate, flange mounted on ducts, using sheet metal screws. They shall

be similar to the piping thermometers specified above with the addition of a perforated bulb guard.

.3 Thermometers located over 2.7 m (9 ft.) above floor shall be remote mounted dial type Trerice model L-80341, or approved alternate, with 115 mm (4½ in.) stainless steel case back flange, liquid filled, bottom outlet, connecting tubing, brass movement, bronze bearings, stainless steel pointer, glass window and white background and black markings and be mounted on a steel or aluminum plate at eye level. Remote bulb shall be brass for piping and coiled copper for ductwork.

.4 Acceptable Manufacturers, subject to shop drawing review: Ashcroft, U. S. Gauge, Weiss Instruments, Winter's Thermogauges Ltd., or approved alternate.

.5 Thermometer scale ranges shall be as follows:

Combination Systems	Scale Range
Domestic hot water	0 °C to 82 °C (30 °F to 180 °F)

2.3 Pressure gauges

.1 Pressure gauges shall be Trerice model 600CB, or approved alternate, with 115 mm (4½ in.) diameter black finished cast aluminum case, brass socket, phosphor bronze bourdon tube, bronze movement glass window, and suitably sized Trerice model 872 snubber or approved alternate. Bourdon tube shall be silver brazed at socket and at linkage. Dial shall be white finish with black figures and graduations, mounted on movement assembly independent of gauge casing. Scales shall be combined (metric/Imperial). Operating pressure indication shall fall in middle 1/3 of scale range, if scale range is not otherwise indicated. Install a Schedule 80 seamless steel siphon in line to gauges on steam service. Gauges shall be 115 mm (4½ in.) diameter unless specified otherwise.

.2 Acceptable Manufacturers, subject to shop drawing review: Ashcroft, U. S. Gauge, Weiss Instruments, Winter's Thermogauges Ltd., or approved alternate.

2.4 Water meters

.1 Water meters shall be in accordance with the local authorities requirements and as follows:

.1 Size 2 in. (50 mm) and smaller: Neptune Trident T-10 or approved alternate, certified to NSF/ANSI 61, Annex G and F, for cold water measurement with a maximum working pressure of 150 psi (1,034 kPa) and a maximum operating temperature of 80 °F (26.7 °C). The measuring chamber shall include a nutating disc design made from a synthetic polymer.

.2 Size 2½ in. (65 mm) and larger : Neptune Tru/Flo or approved alternate, for cold water measurement with a working pressure of 150 psi (1,034 kPa) and a maximum operating temperature of 80 °F (26.7 °C). The register shall be a direct reading, centre sweep, roll sealed, magnetic drive with a low-flow indicator. The measuring element shall be AWWA Class II turbine, hydrodynamically balanced rotor with a nutating disc.

.2 Remote readout head shall be with attached length of AWG # 20 pulse wire.

.3 Readouts shall be suitable for dual measure (Metric/Imperial) readout.

2.5 Flow Measuring Stations.

.1 Water flow measuring stations shall be Dwyer TE series, or approved alternate, Orifice Plate Flowmeters of PTFE material and Buna-N gasket construction. Orifice plate flow metering packages incorporating a unique holder or carrier ring containing metering taps and integral gaskets.

.2 Temperature Limits: -40 °F to 200 °F (-40 °C to 93.3 °C). Installation: Standard flange

3 Execution

3.1 Installation

.1 Install to devices in accordance with the manufacturer's instructions.

.2 Install positive displacement meters with isolating valves on inlet and outlet to AWWA M6. Provide full line size valved bypass with globe valve for liquid service meters.

.3 Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.

.4 Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide syphon on gauges in steam systems. Extend nipples and syphons to allow clearance from insulation.

.5 Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2⅜ in. (60 mm) for installation of thermometer sockets. Ensure sockets allow clearance from thermal insulation.

.6 Install thermometers in air duct systems on flanges.

.7 Install thermometer sockets adjacent to control systems thermostat, transmitter, or sensor sockets. Where thermometers are provided on local panels, duct or pipe mounted thermometers are provided on local panels, duct or pipe mounted thermometers are not required.

.8 Locate duct mounted thermometers minimum 10 ft. (3 m) downstream of mixing dampers, coils, or other devices causing air turbulence.

.9 Coil and conceal excess capillary on remote element instruments.

.10 Provide instruments with scale ranges selected according to service with largest appropriate scale.

.11 Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 ° off vertical.

.12 Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero (0).

.13 Locate test plugs adjacent thermometers and thermometer sockets.

.14 Maintain 10 diameter upstream and 5 diameter downstream of orifice plate flow measuring station.

End of section

1 General

1.1 Section includes

.1 Sealants

.2 Fire stopping sealants

.3 Sleeves

.4 Flashings and counter-flashings

.5 Escutcheons and plates

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

.2 Read and conform to:

.1 The Contract CCDC 2, Stipulated Price Contract as amended in the Contract Documents;

.2 Division 01 requirements and documents referred to therein.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: physical properties, application limits.

.4 Manufacturer's Installation Instructions.

.5 Submit manufacturer's performance data, certification agency file numbers and catalogue information.

.6 Prepare and submit a schedule of service penetration systems to be employed indicating the ULC listing designation, services involved,

location of opening through fire separation and the components of the fire separation and/or assembly.

1.4 Quality assurance

.1 Manufacturer: Company specializing in manufacture of sealants with minimum three (3) years documented product development, testing, and manufacturing experience.

.2 Fire stop components and assemblies shall be ULC listed and tested in accordance with ULC S115 Standard Method of Fire Test for Fire stop Systems.

1.5 Regulatory requirements

.1 Conform to Ontario Building Code.

.2 Conform to Ontario Fire Code.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Adhesives, sealants, paints and coatings

.1 Adhesives, Sealants, Paints and Coatings: Use only low VOC emitting materials in accordance with Section 01 81 13 – Sustainable Design Criteria. Fire stopping compounds

.2 Manufacturer: 3M products indicated or approved alternate.

.3 Other acceptable manufacturers offering equivalent products.

.1 Dow Corning;

.2 John Manville;

.3 Hilti Firestop Systems; or

.4 Approved alternate.

.4 Fire Rated Sealants: intumescent material, synthetic elastomers, capable of expanding up to eight (8) to ten (10) times when exposed to temperatures of 250 °F (121 °C) or higher. ULC listed and labelled.

.5 Refer to Division 07.

2.3 Sealants and caulking

.1 Refer to Division 07.

2.4 Sleeves

.1 Below grade: Minimum schedule 40 PVC with solvent welded fittings and joints.

.2 Above ground:

.1 Minimum schedule 20 galvanized steel.

.2 Provide sleeves through walls and floors for insulated piping of sufficient size to allow insulation to pass through unbroken, with 13 mm (½ in.) clearance all around; otherwise allow for 25 mm (1 in.) clearance all around. Terminate sleeves flush with walls, 50 mm (2 in.) above floors and 100 mm (4 in.) above roof.

2.5 Escutcheons

.1 One-piece chrome plated brass or #4 finish type 302 stainless steel plates with screws, each sized to cover the pipe sleeve or wall or slab opening, and to fit tightly around the pipe or pipe insulation.

2.6 Flashings and counter flashings

.1 Thaler or approved alternate mechanical/electrical flashings as recommended for specific purpose.

.2 Stainless steel flashing sleeve, integral deck flange and EPDM seal.

3 Execution

3.1 Sealants and caulking

.1 Fill voids around pipes:

.1 Seal between sleeve and pipe in foundation walls and below grade floors with penetration seals (link-seal). Install as per manufacturer's installation instructions.

.2 Where sleeves pass through non-fire rated walls or floors, caulk space between pipe and sleeve with fibreglass. Seal space at each end with waterproof, fire retardant, non-hardening mastic.

.3 Ensure no contact between copper tube or pipe and ferrous sleeve.

.4 Fill future-use sleeves with easily removable filler.

.5 Coat exposed exterior surfaces or ferrous sleeves with heavy application of zinc rich paint (VOC content not to exceed 250 g/L).

.2 Temporarily plug all openings during construction.

3.2 Fire stopping

.1 All openings in fire separations and fire rated assemblies for service penetrations shall be protected with ULC listed service penetration fire stop systems (SP).

.2 The service penetration fire stop system shall have F and FT ratings equal to or greater than ratings specified by the Architect for the fire separation (F) and firewall (FT) joint fire stop systems (JF).

.3 All components employed in the service penetration fire stop system shall conform to the ULC listing.

.4 Contractor shall prepare and submit a schedule of service penetration fire stop systems to be employed indicating the ULC listing designation, services involved, location of opening through fire separation and the components of the fire separation assembly.

.5 Refer to architectural drawings for ratings of fire separations and assemblies.

3.3 Sleeves and curbs

.1 Provide pipe sleeves at points where insulated and un-insulated pipes pass through masonry or concrete.

.2 Provide sleeves of minimum schedule 20 galvanized steel.

.3 Use steel pipe sleeves with annular fin continuously welded at midpoint:

.1 through foundation walls, with penetration seals.

.2 through floors of mechanical rooms and equipment rooms.

.4 Where piping passes below footings, provide minimum clearance of 2 in. (50 mm) between sleeve and pipe. Backfill up to underside of footing with concrete of same strength as footing with concrete of same strength as footing.

.5 Terminate sleeves flush with surface of concrete and masonry and 2 in. (50 mm) above floors. Not applicable to concrete floors on grade.

.6 Provide watertight concrete curb 4 in. (100 mm) high around mechanical services (pipes, ducts, conduits) which rise through mechanical (service) room floors. Provide minimum 4 in. (100 mm) clearance between openings for services within curbs.

.7 For pipes passing through roofs, use cast iron sleeves with caulking recess and flashing clamp device. Anchor sleeves in roof construction, caulk between sleeve recess and pipe, fasten roof flashing to clamp device, make water-tight durable joint. Co-ordinate with roofing Section.

3.4 Flashings

.1 Provide all flashing at each point where piping passes through the roof.

.2 Coordinate this work with the roofing Trades to ensure a satisfactory installation and to avoid delays.

3.5 Escutcheon plates

.1 Provide on pipes passing through finished walls, partitions, floors and ceilings.

.2 Use chrome or nickel plated brass, solid type with set screws for ceiling or wall mounting.

.3 Inside diameter shall fit around finished pipe. Outside diameter shall cover opening or sleeve.

.4 Where sleeve extends above finished floor, escutcheon or plates shall clear sleeve extension.

.5 Secure to pipe or finished surface, but not insulation.

End of section

1 General

1.1 Section includes

.1 Pipe and equipment hangers and supports

.2 Equipment bases and supports.

.3 Sleeves and seals.

.4 Flashing and sealing equipment and pipe stacks.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 Refer to the latest edition of the following:

.1 ASME B31.1 - Power Piping.

.2 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.

.3 ASME B31.9 - Building Services Piping.

.4 ASTM A 125, Standard Specification for Steel Springs, Helical, Heat-Treated.

.5 ASTM A 307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

.6 ASTM F708 - Design and Installation of Rigid Pipe Hangers.

.7 ASTM A 563, Standard Specification for Carbon and Alloy Steel Nuts.

.8 MSS SP 58, Pipe Hangers and Supports - Materials, Design and Manufacture

.9 MSS SP 69, Pipe Hangers and Supports - Selection and Application

.10 MSS SP 89, Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Submit shop drawings in accordance with Section 20 01 00 – Mechanical General Requirements, for the following items:

.1 Pipe hangers and supports.

.2 Rooftop pipe, duct and equipment supports.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Pipe hangers and supports

.1 Manufacturers:

.1 Anvil;

.2 Myatt;

.3 Hunt; or

.4 Approved alternate.

.2 Hydronic Piping:

.1 Conform to CSA B-51 and ASME B31.9.

.2 Hangers for pipe sizes ½ in. to 1½ in. (13 to 38 mm) shall be carbon steel, adjustable swivel, with a split ring.

.3 Hangers for pipe sizes 2 in. to 4 in. (50 to 100 mm) shall be carbon steel, adjustable, clevis.

.4 Hangers for pipe sizes 6 in. (150 mm) and over shall be adjustable steel yoke, cast iron roll, double hanger.

.5 Multiple pipe or trapeze hangers for pipe sizes up to 4 in. (100 mm) shall be steel channels with welded spacers and hanger rods.

.6 Multiple pipe or trapeze hangers for pipe sizes 6 in. (150 mm) and over shall be steel channels with welded spacers, hanger rods, and cast iron rollers.

.7 Wall support for pipe sizes up to 3 in. (75 mm) shall be cast iron hooks.

.8 Wall support for pipe sizes 6 in. (150 mm) and over shall be welded steel brackets and wrought steel clamps with adjustable steel yoke and cast iron roller.

.9 Vertical supports shall be steel riser clamp.

.10 Floor support for up to 4 in. (100 mm) shall be cast iron adjustable pipe saddles, lock nut, nipple, floor flange, and concrete pier or steel support.

.11 Floor support for pipe sizes 6 in. (150 mm) and over shall be adjustable cast iron roll and stand, steel screws, and concrete pier or steel support

.12 Copper pipe supports shall be carbon steel ring, adjustable, copper plated.

.3 Refrigerant Piping:

.1 Conform to ASME B31.5.

.2 Hangers for pipe sizes ½ in. to 1½ in. (13 to 38 mm) shall be carbon steel, adjustable swivel, with a split ring.

.3 Hangers for pipe sizes 2 in. to 4 in. (50 to 100 mm) shall be carbon steel, adjustable, clevis.

.4 Multiple pipe or trapeze hangers for pipe sizes up to 4 in. (100 mm) shall be steel channels with welded spacers and hanger rods.

.5 Multiple pipe or trapeze hangers for pipe sizes 6 in. (150 mm) and over shall be steel channels with welded spacers, hanger rods, and cast iron rollers.

.6 Wall support for pipe sizes up to 3 in. (75 mm) shall be cast iron hooks.

.7 Wall support for pipe sizes 6 in. (150 mm) and over shall be welded steel brackets and wrought steel clamps with adjustable steel yoke and cast iron roller.

.8 Vertical supports shall be steel riser clamp.

.9 Floor support for up to 4 in. (100 mm) shall be cast iron adjustable pipe saddles, lock nut, nipple, floor flange, and concrete pier or steel support.

.10 Floor support for pipe sizes 6 in. (150 mm) and over shall be adjustable cast iron roll and stand, steel screws, and concrete pier or steel support

.11 Copper pipe supports shall be carbon steel ring, adjustable, copper plated.

.4 Plumbing Piping:

.1 Conform to ASME B31.9.

.2 Hangers for pipe sizes ½ in. to 1½ in. (15 to 38 mm) shall be malleable iron, adjustable swivel, split ring.

.3 Hangers for pipe sizes 2 in. to 4 in. (50 to 100 mm) shall be carbon steel, adjustable, clevis.

.4 Hangers for pipe sizes 6 in. (150 mm) and greater shall be adjustable steel yoke, cast iron pipe rollers, double hanger.

.5 Multiple pipe or trapeze hangers shall be steel channels with welded supports or spacers and hanger rods.

.6 Multiple pipe or trapeze hangers for pipe Sizes 6 in. (150 mm) and greater shall be steel channels with welded supports or spacers and hanger rods, with a cast iron roller.

.7 Wall support for pipe sizes up to 3 in. (75 mm) shall be cast iron hook.

.8 Wall support for pipe sizes 4 in. (100 mm) and greater shall be welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron pipe roll.

.9 Vertical supports shall be steel riser clamp.

.10 Copper pipe support shall be a carbon steel ring adjustable, and be copper plated.

2.3 Accessories

.1 Hanger rods shall be galvanized, carbon steel with continuous threads.

.2 Inserts shall be malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 Rooftop pipe and duct supports

.1 Acceptable manufacturers:

.1 Portable Pipe Hangers, Inc.;

.2 Unistrut;

.3 Tri-Kon Systems;

.4 Roof Top Blox (pipes only); or

.5 Approved alternate.

.2 Pre-engineered pipe/duct support system including;

.1 Bases: Injection moulded high density polypropylene with UV inhibitors and antioxidants with a density of 55.8 lbs/ft.^{3} (894 kg/m^3).

.2 Framing: 1-5/8 in. (41.3 mm) strut or 1-7/8 in. (47.6 mm) strut as required for loading, roll formed three (3) sided tubular shape with perforated 9/16 in. (14 mm) holes at 1-7/8 in. (48 mm) centres on three (3) sides with a t2 gauge thickness. All framing members shall be hot dipped galvanized steels as per ASTM A123 with a mill finish.

.3 Hardware: Hot dipped galvanized steel.

.3 Pipe Supports and Hangers: Conform to MSS SP-58 and MSS SP-69, fabricated of carbon steel. Single roller supports for piping subject to expansion and contraction.

.4 Metal surfaces hot dip galvanized free of roughness, whiskers, unsightly spangles, icicles, runs, barbs, sags, droplets and other surface blemishes. Galvanizing shall conform to ASTM A123 for tubing and to ASTM A153 for hardware and accessories.

.5 Shop Drawings: Manufacturer shall provide detailed shop drawings to indicate layout and supporting capacities of system components with

installation and assembly instructions for each application. Shop drawings shall bear the signature and seal of a professional engineer licensed in the jurisdiction of the project.

3 Execution

3.1 Installation

.1 Install hangers, supplies and attachments as required to properly support from the building structural elements and to the manufacturer's instructions including best trade practises.

3.2 Inserts

.1 Provide inserts for placement in concrete formwork.

.2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

.3 Provide hooked rod to concrete reinforcement section for inserts carrying pipes over 4 in. (100 mm).

.4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

.5 Where inserts are omitted, drill through the concrete slab from below and provide through-bolts with recessed square steel plates and nuts above slab.

3.3 Pipe hangers and supports

.1 Support horizontal piping as scheduled.

.2 Install hangers to provide a minimum ½ in. (13 mm) space between finished covering and adjacent work.

.3 Place hangers within 12 in. (300 mm) of each horizontal elbow.

.4 Use hangers with 1½ in. (38 mm) minimum vertical adjustment.

.5 Support horizontal cast iron pipe adjacent to each hub, with 5 ft. (1.5 m) maximum spacing between hangers.

.6 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

.7 Support riser piping independently of connected horizontal piping.

.8 Provide copper plated hangers and supports for copper piping.

.9 Design hangers for pipe movement without disengagement of supported pipe.

.10 Prime coat exposed steel hangers and supports. Refer to Section 09. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.4 Equipment bases and supports

.1 Provide housekeeping pads of concrete, minimum 4 in. (100 mm) thick and extending a maximum of 6 in. (150 mm) beyond supported equipment. Refer to Section 03.

.2 Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.

.3 Construct supports of steel members. Steel pipe and fittings. Brace and fasten with flanges bolted to structure.

.4 Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 Rooftop pipe and duct support

.1 Coordinate installation of supports and bases with roofing work. Ensure that roofing surfaces are smooth and flat and are ready to receive work.

.2 Use care in installation of support systems not to damage roofing, flashing, equipment or related materials.

.3 Install and secure support systems in strict accordance with manufacturer's written instruction.

.4 Consult manufacturers of roofing system to determine if walk pads are required. Provide and fully adhere walk pads to roof system where required.

.5 Bases and support framing shall be located as indicated on shop drawings provided by support system manufacturer and as specified herein. The support of all piping shall be complete and adequate, whether or not all required devices are shown.

.6 The use of wood or wire for supporting piping will not be permitted.

.7 Deflection of pipes shall not exceed 1/240th of the span.

.8 Accurately locate and align bases. Where applicable, replace gravel around bases. Set framing posts into bases and assemble framing structure as indicated.

.9 Use galvanized fasteners for galvanized framing, and use stainless steel fasteners for stainless steel framing.

3.6 Flashing

.1 Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

.2 Seal roof, floor, shower and mop sink drains watertight to adjacent materials.

.3 Provide curbs for mechanical roof installations 14 in. (350 mm) minimum high above finished roofing surface. Flash and counter flash with sheet metal; seal watertight. Attach counter flashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints.

.4 Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.7 Sleeves

.1 Set sleeves in position in formwork. Provide reinforcing around sleeves.

.2 Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

.3 Extend sleeves through floors 1 in. (25 mm) above finished floor level. Caulk sleeves.

.4 Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with stuffing insulation and caulk. air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

.5 Install chrome plated steel escutcheons at finished surfaces.

3.8 Schedules

.1 For Steel or Iron Pipes

Pipe Diameter mm (ins)	Horizontal Spacing of Supports mm (ins)	Threaded Rod Diameter mm (ins)
13 (1/2)	1500 (60)	10 (3/8)
19 (3/4)	1800 (72)	10 (3/8)
25 (1)	2100 (84)	10 (3/8)
32 (1-1/4)	2400 (96)	10 (3/8)
38 (1-1/2)	2400 (96)	10 (3/8)
50 (2)	2400 (96)	10 (3/8)
65 (2-1/2)	2400 (96)	13 (1/2)
75 (3)	2400 (96)	13 (1/2)
100 (4)	2400 (96)	16 (5/8)
150 (6)	3600 (144)	19 (3/4)
200 (8)	3600 (144)	22 (7/8)

.2 For Copper Tubing, Annealed Steel Tubing or PVC Piping

Pipe Diameter mm (ins)	Horizontal Spacing of Supports mm (ins)	Threaded Rod Diameter mm (ins)
13 (1/2)	1500 (60)	10 (3/8)
19 (3/4)	1500 (60)	10 (3/8)
25 (1)	1800 (72)	10 (3/8)
32 (1-1/4)	2100 (84)	10 (3/8)
38 (1-1/2)	2400 (96)	10 (3/8)
50 (2)	2400 (96)	10 (3/8)
65 (2-1/2)	3000 (120)	13 (1/2)
75 (3)	3000 (120)	13 (1/2)
100 (4)	3000 (120)	16 (5/8)

.3 For Cast Iron (MJ) Pipes

Pipe Diameter mm (ins)	**Horizontal Spacing of Supports mm (ins)**	**Threaded Rod Diameter mm (ins)**
< 75 (3)	1000 (40)	16 (5/8)
>100 (4)	1000 (40)	19 (3/4)

End of section

1 General

1.1 Section includes

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

.2 Read and conform to:

.1 The Contract CCDC 2, Stipulated Price Contract as amended in the Contract Documents;

.2 Division 01 requirements and documents referred to therein.

1.2 Criteria

.1 Equipment shall be adequately isolated to maintain acceptable NC noise levels in occupied areas of the building as outlined in the following schedule. Approved, qualified personnel shall take noise measurements over complete audible frequency range in occupied zones adjacent to mechanical equipment rooms and main duct shafts and in other locations to ensure NC levels are achieved.

.2 Acceptable NC noise levels are as follows:

Classrooms	28 to 30
Office-Private	32 to 34
Open Plan	36 to 38
Conference/Boardrooms	30 to 32

1.3 Shop drawings

.1 Submit shop drawings in accordance with Section 20 01 00 – Mechanical General Requirements for the following items:

.1 A complete set of approved shop drawings of mechanical equipment, piping and ductwork which is to be isolated.

.2 Include as a minimum the basic equipment layout, length and width; installed operating weights of equipment to be isolated and distribution of weight at isolation points.

.3 Product Date

.1 Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details and finishes.

.2 Schedule of vibration isolator type with location and static and dynamic load on each.

.3 Vibration Isolation Base Details:

.1 Detail fabrication, including anchorages and attachments to structure and to supported equipment.

.2 Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment and cantilever loads.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

1.5 Quality assurance

.1 Provide steel welding in accordance with CSA W59, by fabricators certified by the Canadian Welding Bureau to CSA W47.1.

.2 Isolation materials, flexible connectors, and seismic restraints shall be same manufacturer. Select and certify using published or factory certified data.

.3 Vibration isolation manufacturer shall be a member of the Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Acceptable manufacturers

.1 Vibration and noise control equipment shall be as manufactured by:

.1 Vibro-Acoustics Ltd.;

.2 Amber/Booth Company;

.3 Vibron Limited;

.4 Korfund Sampson Ltd.;

.5 Mason Industries; or

.6 Approved alternate.

2.3 Springs

.1 Springs shall be stable, colour coded and selected to operate at no greater than 2/3 solid deflection.

.2 Springs for outdoor or high humidity applications shall have two coats of neoprene.

.3 Outside spring diameter shall be a minimum of 0.8 times rated vertical operating height and the ratio of horizontal stiffness to vertical stiffness (kx/ky) shall be greater than 1.2 times ratio of static deflection to operating height.

2.4 Spring mounts

.1 Spring mounts shall be complete with levelling devices, 6 mm (1/4 in.) thick ribbed rubber sound pad bonded to load plate. Fasteners shall be zinc chromate plated and mounts for outdoor or high humidity applications shall have two coats of neoprene.

.2 Mounts bolted to floor shall be complete with rubber isolation washers.

.3 Type I mounts shall be closed spring type mounts with top and bottom housings separated with neoprene rubber stabilizers.

.4 Type II mounts shall be open spring type mounts with extra stiff springs having a minimum kx/ky of 1.0.

.5 Type III mounts shall be controlled type mount with heavy rigid steel base frames, built-in vertical limit stops and removable spacers. Springs shall be extra stiff having a minimum kx/ky of 1.0. Clearances between metal parts shall be 6 mm (¼ in.) minimum.

2.5 Spring hangers

.1 Type SH shall be welded steel housing with one coat anti-rust paint, complete with colour coded stable spring, retaining cups and acoustic washer.

.2 Type SHR shall be as Type SH but shall have 25 mm (1 in.) elastomeric element in place of acoustic washer

2.6 Pad type isolators

.1 Type AA rubber waffle or ribbed pads shall be of high quality 30 durometer natural rubber, minimum of 13 mm (½ in.) thick and selected for a maximum loading of 350 kPa (50 psi).

.2 Type BB rubber-steel-rubber pads shall consist of two (2) layers of Type AA pad, 13 mm (½ in.) thick, as specified above, bonded to 6mm (¼ in.) steel plates. Holes shall be sleeved and complete with isolation washers.

.3 Type CC pads shall be kinetic neoprene jacketed pre-compressed moulded fibreglass.

.4 Type RLS mounts shall be elastomeric rubber with threaded insert and hold down bolt holes.

.5 Type R mounts shall be neoprene, 50 mm (2 in.) free height with natural frequency not to exceed 15 CPS at full load. Isolator shall be capable of sustaining a load of 110 kg (220 lbs.) with maximum deflection of 5 mm (0.2 in.).

2.7 Bases

.1 Type `A' integral fan and motor bases, complete with motor slide rails welded in place, shall have minimum vertical sections as follows:

Motor kW (HP)	Vertical Sect. mm (inch)
Up to 2.2 (3)	75 (3)
5.4 (7 1.2)	100 (4)
15 (20)	150 (6)
37 (50)	200 (8)
Over 37 (50)	250 (10)

.2 Submit sizes of reinforced bases having smaller vertical sections for approval.

.3 Type "B" channel slings shall be of structural members with gusset plates welded to the ends.

.4 Type "C" reinforced concrete inertia bases shall be a minimum of 1.5x the weight of the isolation equipment and shall be constructed using a full depth channel iron perimeter and reinforcing rods welded in place. The concrete shall be rated at 3,000 (20 MPa). Design shall be by the isolation suppliers

.5 Steel bases and inertia bases shall clear sub-bases by at least 50 mm (2 in.). Block and shim bases level, so that duct and pipe connections can be made to a rigid system at operating level before isolator adjustment.

2.8 Factory built silencers

.1 Refer to Section 23 33 19 – Sound Attenuators in conjunction with the following.

.2 All silencers shall be completely prefabricated of non-combustible materials and shall have a minimum insertion loss and a maximum air pressure drop as shown in `Silencer Schedule'.

.3 Acoustic media shall be placed under compression and protected from air erosion by minimum 0.853 mm (22 gauge) thick perforated galvanized sheet metal liner.

.4 Silencers with internal air velocities above 22.86 m/s (4,500 fpm) shall have acoustic media additionally protected from erosion by glass fibre cloth.

.5 Silencers shall have 50 mm (2 in.) slip connections unless specified otherwise. Silencers shall be painted with anti-rust prime coat. Provide

lifting lugs on silencers with cross sectional dimensions larger than 600mm (24 in.).

.6 Class I silencers of rectangular construction shall have an outer shell of 0.853 mm (22 gauge) thick minimum sheet metal and shall be used in ductwork not in excess of 1,000 Pa (4 in. WG) or the design pressure of the silencer, whichever is lower.

.7 Class 2 silencers of rectangular construction shall have an outer sheet of 1.55mm (16gauge) thick sheet metal with continuous welded seams and painted with one anti-rust prime coat. Splitter shall be reinforced with formed channels. End connections shall be steel angle flanges. They shall be used in ducts over 1,000 Pa (4 in. WG).

.8 Circular silencers shall be all welded construction with a minimum 1.60 mm (16 gauge) sheet metal outer shell and 0.853 mm (22 gauge) perforated sheet metal inner shell for diameter over 600 mm (24 in.). For smaller sizes 1.31 mm (18 gauge) and 0.701 mm (24 gauge) respectively shall be acceptable.

.9 Submit certified data of pressure drop, insertion loss and generated noise of silencers. Data shall be certified by a qualified independent testing laboratory.

.10 Insertion loss shall consist of sound pressure level in the diffuse sound field of a reverberant room where a silencer is substituted for the same length of empty duct and the remainder of the system unchanged.

.11 Test method used by the independent testing laboratory certifying the silencer data shall be fully described.

.12 Certification of the pressure drop, insertion loss and generated noise data shall be based upon tests of the same silencer for all measurements.

2.9 Vibration isolating roof curbs

.1 Provide a matching vibration isolating roof curb, for each roof top A/C unit so specified. Equivalent to Mason RSC-DB or approved alternate.

.2 Curbs shall be selected based on manufacturer's data provided for the actual units to be installed. Isolation shall be steel spring type, 50 mm (2 in.) deflection, stabilized to prevent lateral movement of the roof top units in excess of 6 mm (¼ in.).

.3 Curbs shall incorporate neoprene or other approved weatherproofing sheet to completely seal the space between the top and bottom rails.

.4 Springs shall be cadmium plated and hardware shall be cadmium plated or galvanized.

.5 The floating member of the curb shall be fitted with two layers of 15 mm (½ in.) waterproof drywall, with staggered joints. The floating member shall incorporate perimeter steel flanges and intermediate cross members across the curb to support the drywall. The drywall shall be tight to the ducts or any other penetrations. Flexible duct connections shall be installed below.

3 Execution

3.1 Installation

.1 ‘T’ shaped concrete inertia pump bases shall be used only where shown.

.2 Equipment not specifically named in the application of isolation shall be isolated with deflection required to meet noise criteria.

.3 Isolate motor driven mechanical equipment (except propeller fans, domestic water, in-line circulators and sump and sewage pumps).

.4 Isolate equipment containing water, such as refrigeration machines and cooling towers, where draining or flooding results in unloading and loading spring forces with Type III mounts having built-in limit bolts.

.5 Mount base mounted pumps, air compressors and reciprocating refrigeration compressors on concrete inertia bases, unless specifically detailed otherwise. Mount bases on vibration isolators as described herein. Extend each inertia slab sufficiently beyond vertical pipe connections to equipment so that base elbows may be bolted and grouted to slab. Provide air compressors with braided metallic flexible pipe connectors. Give special consideration to single cylinder air compressors to ensure that unbalanced forces are suitably restrained. Include flexible pipe hose connector on rupture disc refrigerant relief vent line. Hose and its liner shall be suitable for refrigerant used. Minimum hose working pressure shall be 1,035 kPa (150 psi).

.6 Provide pipe connections of nominal size up to and including 300 mm (12 in.) diameter on isolated pumps with flanged steel spool pieces for future installation, if required, of flexible hoses.

.7 Locate spool pieces between system isolating valve and pump. Flange to flange lengths of spool pieces shall be as follows:

Pipe Size mm (inches)	Length mm (inches)
50 (2)	450 (18)
65-75 (2 1/2 and 3)	616 (24)
100-125 (4 and 5)	625 (25)
150-300 (6 to 12)	635 (25 1/2)

.8 Equip centrifugal pumps over 2.2 kW (3 hp) except basement located pumps, with box type recessed open spring mounts, located under corners and projections of inertia bases.

.9 Equip centrifugal pumps, 2.2 kW (3 hp) or less, except with basement mounted pumps with rubber-steel-rubber pads, Type "BB" or rubber-in-shear isolators, Type "RLS" located under corners and projections of inertia bases.

.10 Equip basement located pumps and equipment with rubber-steel-rubber pads, Type "RSR" located as described above.

.11 Support equipment such as fans, heating convertors, heat exchangers, packaged boilers, inter-coolers, water and steam header assemblies condensate receivers, deaerator and domestic hot water tanks, located in mechanical equipment rooms, mechanical areas and fan rooms above a basement lowest level and including any mezzanine levels, on spring vibration isolators, located as required so that piping systems and equipment connected to same shall be completely isolated from the building structure.

.12 Support the above equipment when located in mechanical equipment rooms, mechanical areas or fan rooms at a basement lowest level where floor slab is directly in contact with ground, on rubber-steel-rubber pads Type "BB". Isolate equipment, mounted in rooms or areas over excavated crawl spaces with spring vibration isolators.

.13 Locate isolation for equipment as necessary to provide a stable support under saddles, frames and projections of equipment.

.14 Resiliently support piping 63 mm (2½ in.) size and larger located within pipe shafts, duct shafts, equipment and fan rooms, and also first two hangers on such piping leaving these rooms or areas with combination spring hangers or spring mounts. This shall include piping in any cooling tower areas which are open to outside and piping in other locations where spring isolators are specifically indicated. Nearest point of support to any piece of isolated equipment shall have an operating static defection of twice equipment isolator deflection but not more than 50mm (2 in.). Next two supports shall have a static deflection, equal to isolator deflection but not more than 50 mm (2 in.). Other spring hangers and spring mounts shall have a minimum static deflection of 25 mm (1 in.). Provide spring hangers at first two support locations of all piping either side of building expansion joints.

.15 All piping from heating pumps shall be supported with minimum 25 mm static deflection spring mounts or hangers as follows:

Pipes up to 100 mm (4 in.) diameter	First 3 points of support
125 mm (5 in.) to 200 mm (8 in.) diameter	First 4 points of support
250 mm (10 in.) diameter and over	First 6 points of support

.16 Transition from duct sizes indicated to silencer sizes note in Silencer Schedule.

End of section

1 General

1.1 Section includes

.1 Engineering, design and calculations for seismic restraint.

.2 Seismic restraints for equipment, piping and ductwork.

.3 Coordination with Section 20 05 29 – Bases, Hangers and Supports.

.4 Coordination with Section 20 05 48 – Vibration and Noise Control.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Results of Section 20 05 00.

.2 Read and conform to:

.1 The Contract CCDC 2, Stipulated Price Contract as amended in the Contract Documents;

.2 Division 01 requirements and documents referred to therein.

1.3 References

.1 Ontario Building Code.

.2 American National Standards Institute (ANSI).

.3 American Society of Testing and Materials (ASTM) A36/A36M Specification for Carbon Structural Steel.

.4 American Society of Testing and Materials (ASTM) E488 Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.

.5 ASHRAE Standard "A Practical Guide to Seismic Restraint"

.6 Canadian Standards Association (CSA) W59 for welding

.7 CAN/CSA-S832, Guideline for Seismic Risk Reduction of Operation and Function Components (OFCs) of Buildings

.8 Manufacturers Standardization Society (MSS) ANSI/MSS SP-127, Bracing for Piping Systems: Seismic-Wind-Dynamic Design, Selection, and Application

.9 NFPA 13

.10 SMACNA “Seismic Restraint Manual: Guidelines for Mechanical Systems”.

.11 SMACNA "HVAC Duct Construction Standards".

.12 Underwriters Laboratories of Canada (ULC).

.13 Good engineering practice

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 All vibration isolation and seismic restraint systems shall be by one manufacturer.

.4 Submit shop drawings for all devices specified herein and as indicated on the drawings. Submittals shall include dimensions, materials, attachment and anchorage requirements. Indicate compliance with each specification item herein.

.5 Provide calculations for selection of seismic restraints, certified by a qualified professional engineer licensed in the jurisdiction where the project is located.

.6 Written certification from a professional engineer stating that supports systems, anchorage and equipment have been designed according to requirements for a post-disaster structure at time of shop drawing submittals

.7 Shop Drawings:

.1 Provide detailed drawings of all seismic control measures for equipment, ductwork, and piping that is to be seismically restraint.

.2 Provide separate shop drawings for each isolated system complete with performance and product data, indicating all calculations for loads and deflections.

.3 Indicate inertia bases and locate vibration isolators, with static and dynamic loads on each.

.4 Shop drawings shall include engineering calculations for all seismic restraints and attachment including combining shear and tensile loads. A Professional Engineer shall sign, seal and date the calculations.

.5 Product Data: details of materials, construction, dimensions of individual components, installation details, and finishes. Schedule of seismic control component type with location and static and dynamic load on each. For interlocking snubbers; include load deflection curves up to 13 mm (½ in.) deflection in x, y, and z planes.

.6 Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.

.7 Manufacturer's Certificate: Certify that isolators are properly installed and adjusted to meet or exceed design requirements.

1.5 Definitions

.1 Relevant Importance Category for the Building in accordance with the Ontario Building Code:

.1 Post-disaster: buildings which are required to be operational after a disaster.

.2 SFRS: acronym for Seismic Force Resisting System.

.3 SCS: acronym for Slack Cable Restraint System

1.6 Summary

.1 This section covers design, supply and installation of complete SFRSs for all equipment, ductwork, and piping.

.2 SFRS shall be fully integrated into and compatible with noise and vibration controls.

.3 Systems and equipment shall be required to be operational during and after a seismic event.

.4 During a seismic event, SFRS shall prevent systems and equipment from causing personal injury and from moving from normal position

1.7 Project record documents

.1 Record actual locations of seismic restraints including attachment points.

1.8 Seismic engineer

.1 Professional Engineer holding a Certificate of Authorization where the work is to be performed (i.e. Province of Ontario) with a minimum of five (5) years' experience in seismic design, and minimum of $1 million Professional Liability Insurance including Errors and Omissions Insurance.

.2 At the completion of the project, the Seismic Engineer shall review the installations on site, and shall prepare a written report, with a letter signed, sealed and dated by the Seismic Engineer, certifying that the installations have been completed in accordance with their design and shop drawings.

1.9 Seismic control measures

.1 A single Supplier shall provide seismic design, vibration isolation, and seismic restraint. Coordinate with Section 20 05 48 – Vibration and Noise Control.

.2 Seismic restraints are to be provided for all operational and functional components of building services in accordance with current requirements of the Ontario Building Code.

.3 Cable restraint systems, rod stiffener clamps and seismic isolator capacities shall be verified by an independent test laboratory.

.4 Connection materials shall be selected by and site specific designs to be prepared by the Seismic Engineer. The Seismic Engineer may select and specify materials and anchors to be provided by the contractor where this is appropriate.

.5 Contractor shall ensure that the Seismic Engineers' requirements and specification are met.

1.10 Extra materials

.1 Furnish extra materials described below which match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

.1 Seismic Snubber Units: Furnish replacement neoprene inserts for snubbers

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Resilient Isolation Washers and Bushings: One-piece, moulded neoprene, having a durometer 50, plus or minus 5, with a flat washer face.

.2 Seismic Snubbers: Factory fabricated using welded structural steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

.3 Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.

.4 Anchor Bolts: Seismic-rated, drill-in, and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488. All isolation and seismic restraint products supplied by common manufacturer / supplier

2.3 Finishing

.1 Manufacturer's standard paint applied to factory-assembled and factory-tested equipment, before shipping.

.2 Powder coating on springs and housings.

.3 Electro-galvanize hardware.

.4 Hot-dip galvanize metal components for exterior use.

.5 Baked enamel coat metal components for interior use.

.6 Color-code or otherwise mark vibration isolation and seismic control devices to indicate capacity range.

2.4 Seismic force restraint system (SFRS)

.1 Provide seismic restraints for all equipment, ductwork and piping covered by Mechanical Contractor except as noted herein.

.2 Piping and ductwork crossing building expansion joints shall have provision for building motion.

.3 Provide seismic restraints for all flues with a minimum of one (1) transverse and one (1) lateral brace. Restraints shall be designed as per ductwork of equivalent weight.

.4 Fasteners and attachment points shall resist the same load as seismic restraints.

.5 The SFRS shall provide gentle and steady cushioning action and avoid high impact loads.

.6 Provide positive seismic and wind restraints on those systems and components required by the Ontario Building Code and the Authority Having Jurisdiction (AHJ).

.1 Design Spectral response acceleration for short periods, $S_a(0.2)$ shall be 0.150

.2 Site Classification, shall be C

.3 Acceleration based site coefficient, F_a shall be 1.0

.4 Importance Factor for Earthquake Loads, I_E shall be 1.5

.5 Wind reference velocity pressure, q (1/50 year) shall be 0.36 kPa

.7 Design and installation of SFRS shall follow the guidelines listed in CAN/CSA-S832 and the SMACNA Seismic Restraint Manual (unless specifically overridden by this Section). Where contradictions occur the more stringent requirement shall be followed.

.8 Unless indicated otherwise, seismic restraints shall be capable of a minimum 2 g horizontal force in any direction.

.9 The SFRS shall restrain seismic forces in all directions.

.10 SFRS of Piping systems shall be compatible with:

.1 Expansion, anchoring and guiding requirements.

.2 Equipment vibration isolation and equipment SFRS.

.11 SFRS utilizing cast iron, threaded pipe, and other brittle materials shall not be permitted.

.12 Attachments to concrete structure:

.1 Use high strength mechanical expansion anchors.

.2 Drilled or power driven anchors shall not be permitted.

.13 Seismic control measures shall not interfere with integrity of fire stopping.

.14 The SFRSs shall be from a single manufacturer, acceptable manufacturers:

.1 Kinetics Noise Control Inc.;

.2 Mason Industries Inc.;

.3 Vibro-Acoustics (Swegon Group);

.4 Gripple Inc.; or

.5 Approved alternate.

2.5 SFRS for static equipment and systems

.1 Floor-mounted equipment and systems:

.1 Anchor equipment to equipment supports.

.2 Anchor equipment supports to structure.

.3 Use size of bolts scheduled in approved shop drawings.

.2 Suspended equipment and systems:

.1 Use one or combination of following methods:

.2 Install tight to structure.

.3 Cross-brace in all directions.

.4 Brace back to structure.

.5 Slack cable restraint system.

2.6 Slack cable restraint (SCS)

.1 Seismic cable sway bracing restraints shall consist of galvanized steel aircraft cable sized to resist seismic loads with a safety factor of five (5). Cable end connections shall use heavy brackets, thimbles, and wire rope clips or compression sleeves.

.2 The SCS shall prevent sway in the horizontal plane, “rocking” in the vertical plane, sliding and buckling in an axial direction.

.3 Hanger rods shall be braced to withstand compressive loading and buckling.

3 Execution

3.1 Installation of seismic force restraint system

.1 General:

- .1 Restraining devices must be placed on all sides of equipment.
- .2 Secure all control panels to withstand seismic loading.
- .3 Provide additional steel brackets, inserts, bolts, cable, etc. to provide seismic restraints.
- .4 For vibrating equipment:
  - .1 The installation of seismic restraints shall not compromise vibration isolation capabilities.
  - .2 Install vibrating equipment on seismically rated isolators whenever possible.
  - .3 Where seismically rated isolators cannot be used on vibrating equipment, use non-seismic isolators and provide slack cable restraints.
- .5 For non-vibrating equipment, secure the equipment to the structure by:
  - .1 Bolting directly to the structure.
  - .2 Use rigid seismic restraints.
  - .3 Use taught cable restraints - not slack.
  - .4 Rigid restraints are preferable to cable restraints as cables have no compression load capabilities.

.6 Secure brackets.

.7 Inserts shall be installed in accordance to the manufacturer's recommendations.

.8 Prior to the installation of any seismic restraints review with the Structural Consultant the methods of attachment and loads. Be particularly aware of large loads and light steel structures.

.9 Where hanger length for piping, ductwork or equipment at a seismic bracing point exceeds 50f, provide additional rod support in accordance to SMACNA or use Mason SRC clamps.

.10 Eleven (11) months after substantial performance, re-torque all bolts for seismic attachment and provide certificate.

.11 Where anchor bolt diameter is smaller than bolt hole, such as for a slot hole, use Mason 0.5 fast epoxy putty to fill gaps.

.2 Ductwork:

.1 Provide traverse bracing 9 m o.c. maximum. (Except rectangular ducts 1,550 mm and larger in either direction may be braced at 9.8 m o.c.)

.2 Provide longitudinal bracing at 18.3 m o.c. maximum. Transverse bracing for one duct section may also act as longitudinal bracing for a duct section connected perpendicular to it, if the bracing is installed within four feet of the intersection of both ducts and bracing is sized for the larger duct. Duct joints shall conform to SMACNA Duct Construction Standard. All joints in duct sections shall provide a positive fastening together of the section.

.3 A group of ducts may be combined in a larger size frame using the overall dimensions with maximum weight for selection of the members from the schedule on sheet 17 of the SMACNA Guidelines.

.4 Walls (including gypsum-board non-bearing partitions) which have ducts running through them may replace a typical transverse brace. Provide solid blockings around duct penetration at stud wall construction.

.5 Install ducts and pipes not braced with 1,150 mm minimum clearance to vertical ceiling hanger wires.

.6 All sheet metal for bracing to be F_y (yield strength) = 33,000 psi.

.7 Minimum sheet metal for bracing to be 16 ga.

.8 It is the responsibility of the contractor to ascertain that an appropriate size device be selected for each individual piece of equipment.

.3 Piping:

.1 Provide restraint details on piping and equipment as follows.

.2 Vertical Piping:

.1 Attachment - Secure vertical piping at sufficiently close intervals to keep the pipe in alignment and carry the weight of the pipe and contents. Stacks shall be supported at their bases and, if over 2 stores in height, at each floor by approved metal floor clamps.

.2 Screwed pipe - Screwed pipe (I.P.S.) shall be supported at not less than every other storey height.

.3 Copper tubing - Copper tubing shall be supported at each storey for piping 40 mm (1½ in.) and larger diameter, and at not more than 1.8 m (6 ft.) intervals for piping 40 mm (1½ in.) and smaller in diameter.

.4 Support pipes of other materials in accordance with the capability of the pipe to resist seismic loads.

.3 Horizontal Piping:

.1 Supports - Horizontal piping shall be supported at sufficiently close intervals to keep it in alignment and prevent sagging.

.2 Screwed pipe - Screwed pipe (I.P.S.) or flanged pipe shall be supported at approximately 3 m (10 ft.) intervals.

.3 Copper tubing - Copper tubing shall be supported at approximately 1.8 m (6 ft.) intervals for tubing 40 mm (1½ in.) and smaller in diameter and 3 m (10 ft.) intervals for tubing 50 mm (2 in.) and larger id diameter.

.4 Support pipes of other materials in accordance with the capability of the pipe to resist seismic loads.

.4 Provide transverse bracings at 12.2 m (40 ft.) o.c. maximum unless otherwise noted.

.5 Provide longitudinal bracings at 24.4 m (80 ft.) o.c. maximum unless otherwise noted. When thermal expansion or contraction is involved, provide longitudinal bracings at anchor points. The longitudinal braces and the connections must be capable of resisting the force induced by expansion and contraction.

.6 Transverse bracing for one pipe section may also act as longitudinal bracing for the pipe section connected perpendicular to it, if the bracing is installed within 600 mm (24 in.) of the elbow or tee of similar size.

.7 For threaded piping the flexibility may be provided by the installation of swing joints. In welded or solder joint piping the flexibility shall be provided by expansion loops or manufactured flexible connectors. For piping with manufactured ball joints select length of piping offset using "Seismic Drift" in place of "Expansion per Joint" in the manufacturer's selection table. Seismic Drift = 0.015 ft. per foot of height (15 mm/m of height).

.8 Do not use branch lines to brace main lines.

.9 Trapeze hangers may be used. Provide flexibility in joints where pipes pass through building seismic or expansion joints, or where rigidly supported pipes connected to equipment with vibration isolators.

.10 A rigid piping system shall not be braced to dissimilar parts of a building or two dissimilar building systems that may respond in a different mode during an earthquake. Examples: wall and a roof; solid concrete wall and a metal deck with lightweight concrete fill.

.11 Provide large enough pipe sleeves through walls or floors to allow for anticipated differential movements.

.12 At vertical pipe risers, wherever possible, support the weight of the riser at a point of points above the centre of gravity of the riser. Provide lateral guides at the top and bottom of the riser, and at intermediate points not to exceed 9.2 m (30 ft.) o.c.

.13 Cast iron pipe of all types, glass pipe and any other pipe joined with a shield and clamp assembly where the top of the pipe is 30 mm (12 in.) or more from supporting structure shall be braced on each

side of a change in direction of 90 ° or more. Riser joints shall be braced or stabilized between floors.

.14 For gas piping, the bracing details, schedules and notes may be used except that transverse bracing shall be at 6.1 m (20 ft.) o.c. maximum and longitudinal bracing at 12.2 m (40 ft.) o.c. maximum. NPS 1 in., 1¼ in., 1½ in. and 2 in. (25, 32, 40 & 50 mm) diameter pipes shall be braced the same as NPS 2½ in. (65 mm) diameter pipe in the schedule. (No bracing is required for pipes NPS ¾ in. (20 mm) diameter and smaller.)

.15 The seismic bracing and support of fire sprinkler piping is not part of this specification.

.16 It is the responsibility of the contractor to ascertain that an appropriate size restraint device be selected for each individual piece of equipment. Submit details on shop drawings.

.4 Attachment point and fasteners:

.1 Shall withstand the same maximum load that the seismic restraint is to resist and in all directions.

.2 Pipe installation shall comply with the most stringent requirement of MSS SP-127 or as indicated below.

.3 Install SFRS at least 25 mm (1 in.) from all other equipment, systems, and/or services.

.4 Where specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

.5 Co-ordinate connections with all disciplines.

.6 Vertical tanks:

.1 Anchor through housekeeping pad to structure.

.2 Provide steel bands above center of gravity.

.7 Horizontal tanks:

.1 Provide at least two (2) straps with anchor bolts fastened to structure.

3.2 Installation of slack cable restraint systems

.1 Connect to suspended equipment so that axial projection of wire passes through center of gravity of equipment.

.2 Arrange bushing assemblies for anchor bolts for floor mounted equipment with resilient media between the anchor bolt and mounting hole in concrete base.

.3 Arrange bushing assemblies for anchor bolts for wall mounted equipment with resilient media where equipment or equipment mounting channels are attached to the wall.

.4 Alignment of restraints shall be installed to avoid bending of cables at connection points or across edges of adjacent equipment or building structure.

.5 Piping systems shall provide for transverse SCS at 12.2 m (40 ft.) spacing maximum, longitudinal SCS at 24.4 m (80 ft.) maximum or as limited by anchor/slack cable performance.

.6 Ducted systems shall provide for transverse SCS at 9.1 m (30 ft.) spacing maximum, longitudinal SCS at 18.3 m (60 ft.) maximum or as limited by anchor/slack cable performance.

.7 Brace a change in direction longer than 3.7 m (12 ft.)

.8 Small pipes may be rigidly secured to larger pipes for restraint purposes, but not the reverse arrangement.

.9 Orient restraint wires on ceiling hung equipment at approximately 90 ° to each other (in plan), tie back to structure at maximum of 45 ° to structure.

.10 Adjust restraint cables so that they are not visibly slack but permit vibration isolation system to function normally.

.11 Tighten cable to reduce slack to 38 mm (1½ in.) under thumb pressure. Cable shall not support weight during normal operation.

3.3 Exemptions

.1 Exemptions to SFRS shall be in accordance with the SMACNA Seismic Restraint Manual, and the Ontario Building Code:

.1 Rectangular ducts less than 0.56 m^2. (6 $ft.^2$) in cross-sectional area.

.2 Round ducts less than 700 mm in diameter.

.3 Gas, fuel and steam piping less than 25 mm inside diameter.

.4 Piping in boiler and mechanical rooms less than 32 mm (1¼ in.) in diameter.

.5 All other piping less than 65 mm (2½ in.) in diameter.

.6 Equipment rigidly attached to piping or ductwork less than 34 kg (75 lbs.) in weight.

.7 Equipment independently hung or flex connected less than 9 kg (20 lbs.) in weight.

.8 Wall mounted equipment less than 9 kg (20 lbs.) in weight.

.9 Base mounted equipment with no overturning moment, containing no hazardous material, less than 181 kg (400 lbs.) in weight, and is mounted on a stand less than 1200 mm (4 ft.) in height.

.10 All piping suspended by individual hangers 300 mm (12 in.) or less as measured from the top of the pipe to the bottom of the support where the hanger is attached. However, if the 300 mm (12 in.) limit is exceeded by any hanger in the run, seismic bracing shall be provided for the entire run.

.11 The 300 mm (12 in.) exemption applies for trapeze supported systems if the distance as measured from the point of attachment to the trapeze to the point of attachment to the structure is less than 300 mm (12 in.). Structural connections shall be a non-friction connection (no “C” clamps)

3.4 Manufacturer's field services

.1 Examine systems to Section 20 01 00 – Mechanical General Requirements.

.2 Inspect isolated equipment after installation and submit report. Include static deflections.

End of section

1 General

1.1 Section includes

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.2 References

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

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit list of wording, symbols, letter size, and colour coding for mechanical identification.

.4 Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

.5 Product Data: Provide manufacturers catalogue literature for each product required.

.6 Manufacturer's Installation Instructions: Indicate special procedures, and installation.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Nameplates

.1 provide laminated plastic plates with black face and white text with a minimum size of 3½ in. x 1½ in. x 3/32 in. (90 mm x 40 mm x 2 mm), engraved with ¼ in. (6 mm) high lettering. Use 1 in. (25 mm) lettering for major pieces of equipment.

.2 Fasten nameplates securely in a conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.

.3 Identify equipment type, designation and service of areas or zone of building served.

.4 For each item of equipment which may be started automatically or remotely, add a red lamacoid plate, 2½ in. x 9 in. (60 x 230 mm), reading:

"WARNING. THIS EQUIPMENT IS AUTOMATICALLY CONTROLLED AND MAY START AT ANY TIME."

2.3 Tags

.1 Tags: Laminated three-layer plastic with engraved black letters on light contrasting background colour. Tag size minimum 1½ in. (40 mm) diameter.

.2 Chart: Typewritten letter size list in anodized aluminum frame.

2.4 Stencils

.1 Stencils: With clean cut symbols and letters of following size:

.1 ¾ in.- 1¼ in. (20 - 30 mm) Outside Diameter of Insulation or Pipe: 8 in. (200 mm) long colour field, ½ in. (15 mm) high letters.

.2 1½ in. - 2 in. (40 – 50 mm) Outside Diameter of Insulation or Pipe: 8 in. (200 mm) long colour field, ¾ in. (20 mm) high letters.

.3 2½ in. - 6 in. (65 – 150 mm) Outside Diameter of Insulation or Pipe: 12 in. (300 mm) long colour field, 1¼ in. (30 mm) high letters.

.4 8 in. - 10 in. (200 – 250 mm) Outside Diameter of Insulation or Pipe: 24 in. (600 mm) long colour field, 2½ in. (65 mm) high letters.

.5 Over 10 in. (250 mm) Outside Diameter of Insulation or Pipe: 32 in. (800 mm) long colour field, 3½ in. (90 mm) high letters.

.6 Ductwork and Equipment: 2½ in. (65 mm) high letters.

2.5 Self adhesive pipe and duct markers

.1 Vinyl: Factory fabricated vinyl, 0.13 mm (5 mil) thick, preformed to fit around pipe or pipe covering.

.2 Polyester: Factory fabricated polyester, 0.05 mm (2 mil) thick, coated with acrylic adhesive.

.3 Plastic: Factory fabricated plastic film, roll formed, clear laminated to protect lettering.

3 Execution

3.1 Preparation

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

.2 Prepare surfaces for stencil painting.

3.2 Installation

.1 Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear sealer.

.2 Install tags with corrosion resistant chain.

.3 Comply with standard detail on drawings, "Detail of Piping Identification".

.4 Apply stencil markings on all covered piping.

.5 Install plastic tape pipe markers completely around pipe to the manufacturer's instructions.

.6 Label piping that is heat traced or equipped with heating cable "HEAT TRACED", in addition to other identification. Locate such labels adjacent to other identifications.

.7 Install underground plastic pipe markers 6 in. - 8 in. (150 – 200 mm) below finished grade, directly above buried pipe.

.8 Identify air handling units, fans, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

.9 Identify control panels and major control components outside panels with plastic nameplates.

.10 Identify thermostats relating to terminal boxes or valves with nameplates.

.11 Identify valves in main and branch piping with tags. Consecutively number valves in each system.

.12 Identify air terminal units and radiator valves with numbered tags.

.13 Tag automatic controls, instruments, and relays. Key to control schematic.

.14 Identify piping, concealed or exposed, with stencilled painting and plastic tape pipe markers. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 ft. 0 in. (6.0 m) on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

.15 Identify covered ductwork with stencilled painting and bare ductwork with plastic tape duct markers. Identify ductwork with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.

.16 Provide colour coded self-adhesive dots to locate valves or dampers above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.3 Schedules

.1 Consult the Owner and identify piping, ductwork and equipment as directed;

.1 Conforming to the Owner's existing identification practices, or

.2 Conforming to the following Pipe and Valve Identification Table:

Pipe Marker Legend	Valve Tag Legend	Background Colour	Text Colour
Chilled Water Supply	CHWS	Green	White
Chilled Water Return	CHWR	Green	White
Chilled Glycol Supply	CGS	Green	White
Chilled Glycol Return	CGR	Green	White
Condenser Water Supply	CNDS	Green	White
Condenser Water Return	CNDR	Green	White
Domestic Cold Water	DCWS	Green	White
Dom. Hot Water Supply	DHWS	Green	White
Dom. Hot Water Recirc.	DHWR	Green	White
Heating Glycol Supply	HGS	Green	White
Heating Glycol Return	HGR	Green	White
Non-Potable/Gray Water	NPW	Violet	White
Hot Water Heating Supply	HWS	Green	White
Hot Water Heating Return	HWR	Green	White
Refrigerant Liquid	REFL	Yellow	Black
Refrigerant Suction	REFS	Yellow	Black
Sanitary Sewer	SAN	Green	White
Sprinkler Water	SPR	Red	White
Storm Sewer	STM	Green	None
Vent		Green	White

.2 The above list is to be used as a guideline for colour coding only, and is not intended to supersede lists of other authorities or agencies. (i.e. Ministry of Environment; Ministry of Government Services, Canadian Government Standards Board).

3.4 Manufacture’s nameplate

.1 Provide metal nameplates on each piece of equipment, mechanically fastened with raised or recessed letters.

.2 Include registration plates, Underwriters' Laboratories and CSA approval, as required by respective agency and as specified. Indicate size, equipment model, manufacturer's name, serial number, voltage, cycle, phase and power of motors, all factory supplied.

.3 Locate nameplates so that they are easily read. Do not insulate or paint over plates.

3.5 Flow diagrams and directories

.1 Provide Consultant with one (1) electronic copy in PDF format of flow diagram of approved size for each system. Include tag schedule, designating number, service, function, and location of each tagged item and normal operating position of valves.

.2 Install where agreed with the Owner one (1) copy of each flow diagram and valve schedule mounted in glazed frame. Provide one (1) copy of each in the Operation and Maintenance Manual.

End of section

1 General

1.1 Section includes

.1 Access doors.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: manufacturers catalogue or brochure identifying product features.

.4 Shop drawings indicating materials, finishes, dimensions and methods of attachment.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Manufactures

.1 Manufacturer: Acudor or approved alternate.

.2 Other acceptable manufacturers offering equivalent products, subject to shop drawing review.

.1 Cendrex;

.2 Bilco; or

.3 Approved alternate.

2.3 Access doors

.1 Standard

.1 Model no. UF-5500 or approved alternate; 12 in. x 12 in. (300 mm x 300 mm) and smaller shall be constructed of 20 gauge galvanized steel door and frame; over 15 in. x 15 in. (350 mm x 350 mm) shall be 18 gauge. The door shall include rounded corners and be flush with the one piece frame with a white powder coat finish. The assembly shall include concealed hinges and a standard slot screwdriver operated cam lock. Door sizes shall be as required to suit the field requirements but shall not be less than 8 in. x 8 in. (200 mm x 200 mm).

.2 Concealed/Recessed

.1 Model no. DW-5015 or approved alternate; constructed of 22 gauge galvanized steel door and frame with a drywall taping bead on all sides and concealed hinge. The door shall be recessed 5/8 in. (16 mm). The assembly shall include concealed hinges and a standard slot screwdriver operated cam lock. Door sizes shall be as required to suit the field requirements but shall not be less than 12 in. x 12 in. (300 mm x 300 mm).

.3 Fire Rated

.1 Model no. FB-5060 or approved alternate; constructed of 16 gauge galvanized steel door and frame with a prime coat of white alkyd baked on enamel. The assembly shall include concealed hinges and a standard self-latching bolt operated by a knurled knob. Door sizes shall be as required to suit the field requirements but shall not be less than 12 in. x 12 in. (300 mm x 300 mm).

.2 Refer to the architectural drawings for fire resistance ratings.

3 Execution

3.1 Installation

.1 Supply access doors for access to equipment requiring service, lubrication or adjustment and all concealed valves, cleanouts, trap primers, control and volume dampers, and other such equipment.

.2 Turn over access doors to the appropriate general trade for installation under other sections.

End of section

1 General

1.1 Section includes

.1 Testing, adjustment, and balancing of air systems.

.2 Testing, adjustment, and balancing of hydronic and steam systems.

.3 Sound measurement of equipment operating conditions.

.4 Vibration measurement of equipment operating conditions.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 Ontario Building Code.

.2 Ontario Fire Code.

.3 AABC - National Standards for Total System Balance.

.4 ACG - AABC Commissioning Guideline.

.5 ADC - Test Code for Grilles, Registers, and Diffusers.

.6 ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.

.7 ASHRAE Guideline 0 The Commissioning Process,

.8 ASHRAE Guideline 1 The HVAC Commissioning Process,

.9 ASHRAE Guideline 1.1 HVAC&R Technical Requirements for the Commissioning Process,

.10 ASHRAE Guideline 5 Commissioning Smoke Management Systems

.11 ASTM E779 Determining Air Leakage Rate by Fan Pressurization.

.12 NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

.13 SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

.14 SMACNA HVAC Systems Commissioning Manual.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Submit name of adjusting and balancing agency for approval within 30 days after award of Contract.

.4 Field Reports: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

.5 Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.

.6 Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Consultant and for inclusion in operating and maintenance manuals.

.7 Provide reports in electronic PDF format.

.8 Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.

.9 Test Reports: Indicate data on AABC National Standards for Total System Balance forms. Submit data in Imperial and S.I. Metric units.

.10 All reports shall be prepared in electronic format using MS Word software and all tabulations shall be prepared in electronic format using MS Excel spreadsheet software. Submittals shall include an electronic copy in PDF format.

1.5 Sequencing

.1 Convene a minimum of one (1) week prior to commencing the scope of work of this Section.

.2 Sequence work to commence after completion of the systems. Schedule completion of work before Substantial Completion of Project.

1.6 Scheduling

.1 Schedule and provide assistance in final adjustment and test of life safety system with Fire Authority.

1.7 Coordination

.1 Cooperate with the installing Contractor(s) in advising them of specific scheduling requirements for systems verification.

.2 Provide advice to the installing Contractor(s) regarding the location and installation of devices required to permit system balancing and measurements, prior to start of the installation work.

.3 Coordinate verification of smoke control and automatic sprinkler systems with verification of fire alarm system under Division 28.

1.8 Quality assurance

.1 Perform total system balance to AABC National Standards for Field Measurement and Instrumentation, Total System Balance.

.2 Maintain one (1) copy of each document on site.

1.9 Qualifications

.1 Agency: Company specializing in the testing, adjusting, and balancing of systems under this Section with minimum five (5) years documented experience certified by AABC.

.2 Work shall be performed under the supervision of an AABC certified Test and Balance Engineer, an NEBB Certified Testing, Adjusting and Balancing Supervisor, NBCTA Certified Member, or a registered Professional Engineer experienced in the performance of this work and licensed at the place where the Project is located.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Reference standards

.1 All equipment required for the verification of equipment and systems shall be furnished by the agency employed to conduct the Mechanical Systems Verification.

.2 Testing and measuring equipment used in the verification of the mechanical systems shall be calibrated to give true readings within the accuracy specifications of the equipment used. A certificate of calibration from an independent testing laboratory may be required by the Consultant if there is any reason to suspect that the equipment used is giving erroneous readings. In such an event the verification agency shall re-conduct its verifications.

.3 All equipment used by the agency in its verification of mechanical systems remains the property/responsibility of the agency and is not included in the supply to the project.

3 Execution

3.1 Examination

.1 Verify that systems are complete and operable before commencing work. Ensure the following conditions:

.1 Systems are started and operating in a safe and normal condition.

.2 Temperature control systems are installed complete and operable.

.3 Proper thermal overload protection is in place for electrical equipment.

.4 Final filters are clean and in place. If required, install temporary media in addition to final filters.

.5 Duct systems are clean of debris.

.6 Fans are rotating correctly.

.7 Fire and volume dampers are in place and open.

.8 Air coil fins are cleaned and combed.

.9 Access doors are closed and duct end caps are in place.

.10 Air outlets are installed and connected.

.11 Duct system leakage is minimized.

.12 Hydronic systems are flushed, filled, and vented.

.13 Pumps are rotating correctly.

.14 Proper strainer baskets are clean and in place.

.15 Service and balance valves are open.

.2 Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

.3 Beginning of work means acceptance of existing conditions.

3.2 Preparation

.1 Prepare a TAB Plan that includes strategies and step by step procedures.

.2 Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Consultant to facilitate spot checks during testing.

.3 Provide additional balancing devices as required.

3.3 Installation tolerances

.1 Prepare test reports for pumps, fans, inlets and outlets and as required to complete the work.

.2 Air Handling Systems: Adjust to within plus or minus 5 % of design for supply systems and plus or minus 10 % of design for return and exhaust systems.

.3 Air Outlets and Inlets: Adjust total to within plus 10 % and minus 5 % of design to space. Adjust outlets and inlets in space to within plus or minus 10 % of design.

.4 Hydronic Systems: Adjust to within plus or minus 10 % of design.

3.4 Adjusting

.1 Ensure recorded data represents actual measured or observed conditions.

.2 Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

.3 After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

.4 Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

.5 At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Consultant.

.6 Check and adjust systems approximately six (6) months after final acceptance and submit report.

3.5 Air system procedure

.1 Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

.2 Make air quantity measurements in ducts by pitot tube traverse of entire cross sectional area of duct.

.3 Measure air quantities at air inlets and outlets.

.4 Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

.5 Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

.6 Vary total system air quantities by adjustment of fan speeds. Provide drive changes as required, including variable frequency drives, pulleys, sheaves and belts. Vary branch air quantities by damper regulation.

.7 Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

.8 Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan.

.9 Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

.10 Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

.11 Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating and ventilation.

.12 Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 in.wg. (12.5 Pa) positive static pressure near the building entries.

.13 For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections are properly made and confirm proper operation for automatic variable air volume temperature control.

3.6 Water system procedure

.1 Adjust water systems at all points to provide required or design quantities.

.2 Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

.3 Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

.4 Effect system balance with automatic control valves fully open to heat transfer elements.

.5 Effect adjustment of water distribution systems by means of variable frequency drives, balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

.6 Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.7 Schedules

.1 Equipment requiring testing, adjusting and balancing:

.1 Plumbing Pumps
.2 HVAC Pumps
.3 Air Handling Units
.4 Terminal Heat Transfer Units
.5 Fans
.6 Geo-exchange manifolds and balancing valves
.7 Air Terminal Units
.8 Air Inlets and Outlets

.2 Report Forms

.1 Title Page:

.1 Name of Testing, Adjusting, and Balancing Agency
.2 Address of Testing, Adjusting, and Balancing Agency
.3 Telephone number of Testing, Adjusting, and Balancing Agency
.4 Project name
.5 Project location
.6 Project Architect
.7 Project Engineer
.8 Project Contractor
.9 Project altitude
.10 Report date

.2 Summary Comments:

.1 Design versus final performance
.2 Notable characteristics of system
.3 Description of systems operation sequence
.4 Summary of outdoor and exhaust flows to indicate amount of building pressurization
.5 Nomenclature used throughout report
.6 Test conditions

.3 Instrument List:

.1 Instrument

.2 Manufacturer
.3 Model number
.4 Serial number
.5 Range
.6 Calibration date

.4 Electric Motors:
.1 Manufacturer
.2 Model/Frame
.3 HP/BHP
.4 Phase, voltage, amperage; nameplate, actual, no load
.5 RPM
.6 Service factor
.7 Starter size, rating, heater elements
.8 Sheave Make/Size/Bore

.5 V-Belt Drive:
.1 Identification/location
.2 Required driven RPM
.3 Driven sheave, diameter and RPM
.4 Belt, size and quantity
.5 Motor sheave diameter and RPM
.6 Centre to centre distance, maximum, minimum, and actual

.6 Pump Data:
.1 Identification/number
.2 Manufacturer
.3 Size/model
.4 Impeller
.5 Service
.6 Design flow rate, pressure drop, BHP
.7 Actual flow rate, pressure drop, BHP
.8 Discharge pressure
.9 Suction pressure

.10 Total operating head pressure
.11 Shut off, discharge and suction pressures
.12 Shut off, total head pressure

.7 Air Cooled Condenser:
.1 Identification/number
.2 Location
.3 Manufacturer
.4 Model number
.5 Serial number
.6 Entering DB air temperature, design and actual
.7 Leaving DB air temperature, design and actual
.8 Number of compressors

.8 Heat Exchanger:
.1 Identification/number
.2 Location
.3 Service
.4 Manufacturer
.5 Model number
.6 Serial number
.7 Steam pressure, design and actual
.8 Primary water entering temperature, design and actual
.9 Primary water leaving temperature, design and actual
.10 Primary water flow, design and actual
.11 Primary water pressure drop, design and actual
.12 Secondary water leaving temperature, design and actual
.13 Secondary water leaving temperature, design and actual
.14 Secondary water flow, design and actual
.15 Secondary water pressure drop, design and actual

.9 Cooling Coil Data:
.1 Identification/number
.2 Location

.3 Service
.4 Manufacturer
.5 Air flow, design and actual
.6 Entering air DB temperature, design and actual
.7 Entering air WB temperature, design and actual
.8 Leaving air DB temperature, design and actual
.9 Leaving air WB temperature, design and actual
.10 Water flow, design and actual
.11 Water pressure drop, design and actual
.12 Entering water temperature, design and actual
.13 Leaving water temperature, design and actual
.14 Saturated suction temperature, design and actual
.15 Air pressure drop, design and actual

.10 Heating Coil Data:
.1 Identification/number
.2 Location
.3 Service
.4 Manufacturer
.5 Air flow, design and actual
.6 Water flow, design and actual
.7 Water pressure drop, design and actual
.8 Entering water temperature, design and actual
.9 Leaving water temperature, design and actual
.10 Entering air temperature, design and actual
.11 Leaving air temperature, design and actual
.12 Air pressure drop, design and actual

.11 Air Moving Equipment
.1 Location
.2 Manufacturer
.3 Model number
.4 Serial number

.5 Arrangement/Class/Discharge
.6 Air flow, specified and actual
.7 .Return air flow, specified and actual
.8 Outside air flow, specified and actual
.9 Total static pressure (total external), specified and actual
.10 Inlet pressure
.11 Discharge pressure
.12 Sheave Make/Size/Bore
.13 Number of Belts/Make/Size
.14 Fan RPM

.12 Return Air/Outside Air Data:
.1 Identification/location
.2 Design air flow
.3 Actual air flow
.4 Design return air flow
.5 Actual return air flow
.6 Design outside air flow
.7 Actual outside air flow
.8 Return air temperature
.9 Outside air temperature
.10 Required mixed air temperature
.11 Actual mixed air temperature
.12 Design outside/return air ratio
.13 Actual outside/return air ratio

.13 Exhaust Fan Data:
.1 Location
.2 Manufacturer
.3 Model number
.4 Serial number
.5 Air flow, specified and actual
.6 Total static pressure (total external), specified and actual

.7 Inlet pressure
.8 Discharge pressure
.9 Sheave Make/Size/Bore
.10 Number of Belts/Make/Size
.11 Fan RPM

.14 Duct Traverse:
.1 System zone/branch
.2 Duct size
.3 Area
.4 Design velocity
.5 Design air flow
.6 Test velocity
.7 Test air flow
.8 Duct static pressure
.9 Air temperature
.10 Air correction factor

.15 Duct Leak Test:
.1 Description of ductwork under test
.2 Duct design operating pressure
.3 Duct design test static pressure
.4 Duct capacity, air flow
.5 Maximum allowable leakage duct capacity times leak factor
.6 Test apparatus
.1 Blower
.2 Orifice, tube size
.3 Orifice size
.4 Calibrated
.7 Test static pressure
.8 Test orifice differential pressure
.9 Leakage

.16 Terminal Unit Data:

.1 Manufacturer
.2 Type, constant, variable, single, dual duct
.3 Identification/number
.4 Location
.5 Model number
.6 Size
.7 Minimum static pressure
.8 Minimum design air flow
.9 Maximum design air flow
.10 Maximum actual air flow
.11 Inlet static pressure

.17 Air Distribution Test Sheet:
.1 Air terminal number
.2 Room number/location
.3 Terminal type
.4 Terminal size
.5 Area factor
.6 Design velocity
.7 Design air flow
.8 Test (final) velocity
.9 Test (final) air flow
.10 Percent of design air flow

.18 Sound Level Report:
.1 Location
.2 Octave bands - equipment off
.3 Octave bands - equipment on

.19 Vibration Test:
.1 Location of points:
.1 Fan bearing, drive end
.2 Fan bearing, opposite end
.3 Motor bearing, centre (if applicable)

.4 Motor bearing, drive end

.5 Motor bearing, opposite end

.6 Casing (bottom or top)

.7 Casing (side)

.8 Duct after flexible connection (discharge)

.9 Duct after flexible connection (suction)

.2 Test readings:

.1 Horizontal, velocity and displacement

.2 Vertical, velocity and displacement

.3 Axial, velocity and displacement

.3 Normally acceptable readings, velocity and acceleration

.4 Unusual conditions at time of test

.5 Vibration source (if non-complying)

3.8 Verification checklist

.1 Prepare a series of checklists to record the verification of each item of equipment and each system. Submit a draft of each checklist to the Consultant for review and approval. Discuss comments offered by the Consultant and include improvements as directed.

.2 Checklists shall include the following as a minimum;

.1 A record of the nameplate data for each equipment item and each associated motor,

.2 A list of observations appropriate to the equipment item or system with space adjacent to indicate whether the item was satisfactory or unsatisfactory,

.3 A list of observations appropriate to the equipment item or system with space adjacent to indicate whether the item was satisfactory or unsatisfactory,

.4 Appropriate space for recording comments and/or instructions given during observations.

3.9 Equipment verification

.1 Test the operation of all equipment installed under Division 20, 22, 23 and 25 according to instructions in appropriate articles of this Division. Advise installing contractor of any required adjustments or replacements to ensure that equipment is operating as intended. Retest equipment after adjustment or replacement.

.2 Ensure that the Contractor has given proper advance notification to all persons required to be present as tests are conducted. Refer to Section 20 05 00 – Common Mechanical Work Results.

.3 Instrumentation: Verify installation of air filter gauges, pumps, thermometers, thermometer wells, pitot traverse stations, and flow-measuring devices ensuring that:

.1 Location of points for readings is appropriate to measure what it is intended to measure;

.2 The scale range is appropriate to place the normal reading near mid-range of the scale;

.3 Proper positioning of instrumentation to allow reading from a convenient location, and for easy access.

.4 Filters Inspection: Visually inspect each filter installation. Verify adjustment of latching devices, installation of end spacers in filter boxes, and proper latching and sealing of access doors. Verify the installation of new (clean) filter media after Contractor's start-up procedures.

.5 Pre-start-up Inspection:

.1 Verify proper equipment mounting and setting.

.2 Verify that control, interlock, and power wiring are complete.

.3 Verify proper alignment of motors and drives.

.4 Verify proper piping connections and accessories.

.5 Verify that lubrication is complete.

.6 First Run Observation:

.1 Verify direction of rotation.

.2 Verify setting of safety controls.

.3 Monitor heat build-up in bearings.

.4 Check motor loads against nameplate ratings.

.7 Equipment Checkout:

.1 Verify the proper overload heater sizes.

.2 Verify function of safety and operating controls.

.3 Verify proper operation of equipment.

.4 Report on inspection, observation, and checkout procedures.

.8 Stuffing Boxes and Packing Glands: Verify adjustment of boxes on pump shafts and packing glands on valve stems.

.9 Motor Rotation: Visually inspect and verify the direction of motor rotation. It is possible for motor rotation to have been checked by the electrician when power connections were made on temporary electric power, then when final connections were made to the permanent transformer bank, crossed phasing may reverse the rotation of all three-phase motors on the system.

.10 Overload Heaters: Verify supply voltage to each equipment. If the applied voltage is different from the motor nameplate, determine whether the applied voltage is within the range allowed under the motor guarantee. If not, take the necessary action to have the Contractor change the motor or the applied voltage. When the voltage is off the nameplate value, but within the allowable range, compute the equivalent amperage at nameplate voltage and compare to the overload heater amperage rating range. Then, consider whether the ambient temperature of the starter is above, below, or the same as the ambient temperature are not the same. Advise the Contractor to use overload heaters of higher range for "hot area" starters or ones of lower range for "cold area" starters to compensate the heater trip point for heat gains or losses with the environment.

.11 Alignment of Drives: Verify the alignment of drives, belt and direct coupled, and the adjustment of belt tensioners.

.12 Control Diagrams and Sequences: Provide for coordination with work under the automatic control systems to have the control diagrams and sequences of operation corrected to "as installed", reflecting changes brought about in response to contract modifications and to the more

pragmatic changes in diagrams and sequences to make the installed system control the building systems as intended by the designer.

.13 Safety and Operating Control Setpoints: Systematically verify the safety and operating controls of equipment, including an operational check of associated control sequences.

.14 Fin Straightening: Inspect finned surface heat transfer coils for damaged fins and advise Contractor of repairs required.

.15 Verify that manufacturer's start-up procedures have been performed and that equipment is installed in accordance with the manufacturer's written installation recommendations.

.16 Where work is noted to be done in stages a complete air balance and verification report will be required at the end of each stage.

3.10 Piping systems verification

.1 Review the drawings, specifications, and installed work to ensure that systems may be properly balanced in accordance with drawings. Advise the installing Contractor of any additional requirements for effective balancing.

.2 Complete air balancing must have been accomplished before water balance is verified.

.3 Open all valves to full position, including coil stop valves, close bypass valves, and return line balancing cocks.

.4 Verify that all strainers are clean.

.5 Examine water in system to determine if it has been treated and is clean.

.6 Check and record type and concentration of glycol in systems which require freeze protection.

.7 Check pump rotation.

.8 Check diaphragm expansion tanks to ensure that fill pressure is adequate (re. static head of systems plus 5 psig or 12 psig minimum (35 kPa or 83 kPa minimum).

.9 Check open expansion tanks to make sure they are not air bound and that the system is full of water.

.10 Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Verify that all air is removed from circulating system.

.11 Set all temperature controls so that all coils are calling for full cooling. This should close all automatic bypass valves at coil and chillers. To balance hot water coils, set systems to call for full heating.

.12 Verify operation of automatic bypass valve.

.13 Verify operating temperature of heat exchangers, to design requirements.

.14 Check and record the following items at each cooling and heating element:

.1 Inlet water and air temperatures. Note rise or drop in temperature drain source.

.2 Leaving water and air temperatures.

.3 Pressure drop and flow through each coil.

.4 Pump operating suction and discharge pressure and final total dynamic head and flow are delivered.

.5 Pressure drop across bypass valve.

.6 All mechanical specifications of pumps.

.7 Rated and actual running amperage of pump motor.

.15 Witness all piping tests.

3.11 Air system verification

.1 Review drawings, specifications and installed work to ensure that systems may be properly balanced in accordance with drawings. Advise installing Contractor of any additional requirements for effective balancing.

.2 In air handling systems which include supply fans with variable speed drives, airflows shall be verified to design with all filters clean and with all filters loaded to filter manufacturer's recommended final (change-out) resistance. Motor and drive capacity to accommodate full range of filter loadings shall be verified.

.3 In air handling systems which include supply fans without variable speed drives, air filters shall be verified to design airflows with air filters loaded so

that the air pressure drop through each filter is equal to the average of the manufacturers listed initial resistance and recommended final resistance.

.4 Test and record blower rpm for each fan and air handling unit.

.5 Test and record motor full load amperes.

.6 Make Pitot tube traverse of main supply and obtain operating air quantities at fans.

.7 Test and record system static pressures, suction and discharge.

.8 Test and record system operating re-circulated air quantities.

.9 Test and record system operating outside air quantities.

.10 Test and record entering dry bulb air temperatures (heating and cooling coils).

.11 Test and record entering wet bulb air temperatures (heating and cooling coils).

.12 Test and record leaving dry bulb air temperatures (heating and cooling coils).

.13 Test and record leaving wet bulb air temperatures (cooling coils only).

.14 Measure airflow in all main and zone branch supply and return air ducts.

.15 Test and record airflow at each diffuser, grille, and register.

.16 Witness and verify results of duct leakage tests conducted under Section 23 31 00 – Ductwork.

.17 Tabulate and certify test results on suitable forms and submit Consultant for approval and record. Identity each diffuser, grille, and register as to location and area. Identify and list size, type, and manufacturer of diffusers, grilles, registers, and all testing equipment. Use manufacturer's rating on all equipment to make required calculations.

End of section

1 General

1.1 Section includes

.1 Ductwork insulation

.2 Duct liners

.3 Insulation jackets

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 Refer to the latest edition of the following:

.1 ASTM A167 – Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.

.2 ASTM A240 - Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels for General Applications.

.3 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

.4 ASTM C195 - Mineral Fiber Thermal Insulating Cement.

.5 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.

.6 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.

.7 ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

.8 ASTM C552 - Cellular Glass Thermal Insulation.

.9 ASTM C553 - Standard Specification for Mineral Fibre Blanket Thermal Insulation for Commercial and Industrial Applications.

.10 ASTM C592 - Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).

.11 ASTM C612 - Standard Specification for Mineral Fibre Block and Board Thermal Insulation.

.12 ASTM C916 - Adhesives for Duct Thermal Insulation.

.13 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.

.14 ASTM C1071 - Fibrous Glass Duct Lining Insulation(Thermal Sound Absorbing Material).

.15 ASTM C1126 - Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.

.16 ASTM C1136 - Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

.17 ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

.18 ASTM E96 - Water Vapour Transmission of Materials.

.19 ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.

.20 ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

.21 NAIMA National Insulation Standards.

.22 NFPA 96 – Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

.23 NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.

.24 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

.25 UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

.26 CGSB-Canadian General Standards Board.

.27 CAN/CGSB-51.9 Mineral Fibre Thermal Insulation for Piping and Round Ducting.

.28 CAN/CGSB-51.10 Mineral Fibre Board Thermal Insulation

.29 CAN/CGSB-51.11 Mineral Fibre Thermal Insulation Blanket.

.30 CAN/CGSB-5140 Mineral Insulation, Flexible, Elastomeric, Unicellular, Sheet & Pipe Cover-up.

.31 CAN/CGSB-51-GP-52 Ma Vapour Barrier, Jacket and Facing Material for Pipe, Duct & Equipment Thermal Insulation.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

.4 Manufacturer's Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved.

1.5 Quality assurance

.1 Materials: Flame spread/smoke developed rating of 25/50 or less to ULC S102 and ASTM E84.

1.6 Qualifications

.1 Applicator: Company specializing in performing the work of this section with minimum three (3) years experience.

1.7 Delivery, storage and handling

.1 All material shall be transported, shipped, stored, handled and installed in such a manner as not to degrade the quality, serviceability, or appearance. Material warranties shall not be voided by actions of the Contractor.

.2 Deliver materials to site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

.3 Store insulation in original wrapping and protect from weather and construction traffic.

.4 Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 Environmental requirements

.1 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

.2 Maintain temperature during and after installation for minimum period of twenty (24) hours.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Packaging and labelling: Every package or standard container of insulation, jackets, cements, adhesives, and coatings delivered to project site shall have the manufacturer's stamp or label attached giving the name of the manufacturer, brand and description of material. Insulation materials shall be asbestos-free.

.2 Surface burning characteristics: Materials shall have a flame-spread rating of not more than 25 and a smoke-developed rating of not more than 50, when tested in accordance with NFPA 255, ASTM E84 or UL 723. Insulation materials located exterior to the building perimeter are not required to be fire-rated.

2.3 Glass fibre, flexible

.1 Resin bonded fibrous glass blanket with a damage-resistant, flame retardant, reinforced aluminum foil facing. Johns Manville Microlite FSK Duct Wrap insulation or approved alternate. Duct Wrap Insulation: ASTM C1290, Type III, to a maximum service temperature of 250 °F (121 °C), and ASTM C1136, Type II, facing material. Provide the following:

.1 Type 75: 0.75 lb./ft.^{3} (12 kg/m^3) density: 1½ in, 2 in, 2.2 in or 3 in (38 mm, 51 mm, 56 mm or 76 mm) thickness.

.2 Type 100: 1.0 lb./ft.^{3} (16 kg/m^3) density: 1-1/2 in or 2 in (38 mm or 51 mm) thick, or

.3 Type 150: 1.5 lb./ft.^{3} (24 kg/m^3) density: 1½ in or 2 in (38 mm or 51 mm) thick.

.2 The duct wrap insulation shall consist of a blanket of glass fibers factory-laminated to a foil reinforced kraft (FRK) vapor retarder facing with a 2 in (50 mm) (min.) stapling and taping flange on one edge.

.3 Other acceptable manufacturers offering equivalent products:

.1 Manson Insulation;

.2 Knauf Insulation Inc.;

.3 Owens Corning; or

.4 Other approved alternate.

.4 Insulation: ASTM C553; flexible, non-combustible blanket.

.1 'k' value : ASTM C518,0.27, 0.25 and 0.24 Btu.in/(hr.ft2.°F) or 0.039, 0.036 and 0.035 W/m.°C at 75 °F (24 °C).

.2 Maximum moisture absorption: 0.20 % by volume.

.5 Vapour Barrier Jacket:

.1 Kraft paper with glass fibre yarn and bonded to aluminized film.

.2 Moisture vapour transmission: ASTM E96; 0.02 perm.

.3 Secure with pressure sensitive tape.

.6 Vapour Barrier Tape: Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

.7 Outdoor Vapour Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black colour.

.8 Tie Wire: Annealed steel, 1/16 in. (1.5 mm).

2.4 Glass fibre, rigid

.1 Rigid resin bonded fibrous glass board with a damage-resistant, flame retardant, reinforced aluminum foil facing. Johns Manville Type 814 insulation or approved alternate. Service temperature range 0 °F (-18 °C) to 450 °F (232 °C).

.2 Other acceptable manufacturers offering equivalent products:

.1 Manson Insulation;

.2 Knauf Insulation Inc.;

.3 Owens Corning; or

.4 Other approved alternate.

.3 Insulation: ASTM C612; rigid, non-combustible blanket.

.1 'k' value : ASTM C518,0.23 Btu.in/(hr.ft2.°F) or 0.033 W/m.°C at 75 °F (24 °C).

.2 Maximum moisture absorption: 0.20 % by volume.

.3 Density: 3.0 lbs/ft.^{3} (48 kg/cu m.).

.4 Vapour Barrier Jacket:

.1 Kraft paper with glass fibre yarn and bonded to aluminized film.

.2 Moisture vapour transmission: ASTM E96; 0.04 perm.

.3 Secure with pressure sensitive tape.

2.5 Mineral wool, flexible

.1 Blanket mineral fibre type roll form insulation, 1.5 lbs/ft.^{3} (24.0 kg/m^3.) density, 38 mm (1½ in.) thick, with a factory applied vapour barrier facing. Johns Manville Duct Wrap Type 150 "Microlite" or approved alternate.

.2 Other acceptable manufacturers offering equivalent products:

.1 Knauf Insulation Inc.;

.2 Manson Insulation Products Ltd; or

.3 Other approved alternate.

2.6 Mineral wool, rigid

.1 Preformed rigid mineral fibre board type insulation, 3.0 lb./ft.^{3} (48.1 kg/m^3) density, with a "k" factor of 0.23 at 75 °F (24 °C), with a factory applied reinforced aluminum foil and kraft paper facing. Johns Manville Type 814 "Spin-Glas" or approved alternate.

.2 Other acceptable manufacturers offering equivalent products:

.1 Knauf Insulation Inc.;

.2 Manson Insulation Products Ltd.; or

.3 Other approved alternate.

2.7 Jackets

.1 Canvas Jacket: UL listed.

.1 Fabric: ASTM C921, 220 g/m^2, plain weave cotton treated with dilute fire retardant lagging adhesive.

.2 Lagging Adhesive: Compatible with insulation.

.2 Mineral Fibre (Outdoor) Jacket: Asphalt impregnated and coated sheet, 2.45 kg/m^2.

.3 PVC Plastic

.1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material.

.1 Minimum Service Temperature: -31 °F (-35 °C).

.2 Maximum Service Temperature: 151 °F (66 °C).

.3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.

.4 Maximum Flame Spread: ASTM E84; 25 or less.

.5 Maximum Smoke Developed: ASTM E84; 50 or less.

.6 Thickness: 20 mil (0.5 mm) minimum.

.2 Colour: standard off-white.

.3 Covering Adhesive Mastic: Compatible with insulation, maximum VOC content of 50g/L.

.4 Manufacturer:

.1 Johns Manville Ceel-Co 300 series;

.2 Speedline Smoke Safe;

.3 Proto Corp.; or

.4 Approved alternate.

.4 Aluminum Jacket: ASTM B209.

.1 Thickness: 0.02 in. (0.40 mm) sheet with factory applied polyethylene and kraft paper moisture barrier on inside surface.

.2 Finish: Smooth surface for jacket outside diameters of 8 in. (200 mm) or less, Embossed surface for jacket outside diameters of 10 in. (250 mm) and larger.

.3 Joining: Longitudinal slip joints and 2 in. (50 mm) laps.

.4 Fittings: 0.02 in. (0.40 mm) thick die shaped fitting covers with factory attached protective liner.

.5 Bands: ⅜ in. (9.5 mm) wide; 24 gauge aluminum.

2.8 Accessories

.1 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 20 05 00 – Common Mechanical Work Results. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.

.2 Vapour retarder lap adhesive shall be water based, and fire retardant.

.3 Tapes shall be of cloth reinforced aluminum, soft adhesive with minimum 2 in. (50 mm) width.

.4 Tie wire shall be of 1/16 in. (1.5 mm) ø stainless steel.

.5 Fasteners shall be of ⅛ in. (4 mm) diameter pins, with 1½ in. (38 mm) square clips. Clip pin length to suit insulation thickness.

.6 Bands shall be ½ in. (13 mm) wide ¼ in. (6 mm) thick galvanized steel.

.7 Facing shall be of 1 in. (25 mm) galvanized steel hexagonal wire mesh attached on both faces of insulation.

3 Execution

3.1 General

.1 Do not insulate:

.1 Pre-insulated flexible and rigid ductwork.

.2 Flexible connections. and

.3 Fire dampers

3.2 Examination

.1 Verify that ductwork has been tested before applying insulation materials

.2 Apply insulation after the required tests have been completed and approved by the Consultant.

.3 Verify that surfaces are clean, foreign material removed, and dry.

3.3 Installation

.1 Install insulation to TIAC National Installation Standards.

.2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer's written instructions and as specified.

.3 Ductwork that includes internal acoustical linings shall be thermally insulated on the duct exterior as specified in this section.

.4 Insulated ductwork conveying air below ambient temperature:

.1 Provide insulation with vapour barrier jackets.

.2 Finish with tape and vapour barrier jacket.

.3 Continue insulation through walls, sleeves, hangers, and other duct penetrations.

.4 Insulate entire system including fittings, joints, flanges, and expansion joints.

.5 Insulated ductwork conveying air above ambient temperature:

.1 Provide with or without standard vapour barrier jacket.

.2 Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

.3 Continue insulation through walls, sleeves, hangers, and other duct penetrations.

.4 Insulate entire system including fittings, joints, flanges, and expansion joints.

.6 Ductwork exposed in mechanical equipment rooms and finished spaces below shall be finished with canvas jacket sized for finish painting.

.7 Provide insulation with vapour barrier jacket on all exterior applications. Cover with outdoor aluminum jacket.

.8 External Duct Insulation Application:

.1 Secure insulation with vapour barrier with wires and seal jacket joints with vapour barrier adhesive or tape to match jacket.

.2 Secure insulation without vapour barrier with staples, tape, or wires.

.3 Install without sag on underside of duct work. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct work off trapeze hangers and insert spacers.

.4 Seal vapour barrier penetrations by mechanical fasteners with vapour barrier adhesive.

.5 Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

.9 Duct and Plenum Liner Application:

.1 Adhere insulation with adhesive for 90 % coverage.

.2 Secure insulation with mechanical liner fasteners. Refer to SMACNA Standards for spacing.

.3 Seal and smooth joints. Seal and coat transverse joints.

.4 Seal liner surface penetrations with adhesive.

.5 Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

3.4 Tolerance

.1 Substituted insulation materials: Thermal resistance within 10 % at normal conditions, as materials indicated.

3.5 Duct insulation

.1 Insulate ductwork as follows:

Service	Type	Insulation Thickness ins. (mm)
Air supply rectangular	Rigid	1 (25)
Air supply round	Flexible	1 (25)
Exhaust 72 in. (1.8 m) from outside rectangular	Rigid	3 (75)
Exhaust 72 in. (1.8 m) from outside round	Flexible	3 (75)
Fresh air intake rectangular	Rigid	3 (75)
Exhaust air plenum	Rigid	3 (75)
Ductwork outdoors	Rigid	3 (75)

Service	Type	Insulation Thickness ins. (mm)
Rectangular air supply run outs to terminal units < 120 in. (3.0 m)	Rigid	1 (25)
Round air supply run outs to terminal units < 12 in. (3.0 m)	Flexible	1 (25)

.2 In-line supply duct silencers shall be insulated to match the supply duct insulation.

.3 Ductwork of ERV-1 in Vehicle Bay area does not need to be insulated.

End of section

1 General

1.1 Section includes

.1 Equipment insulation

.2 Covering

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 Refer to the latest edition of the following:

.1 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

.2 ASTM A167 – Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet and Strip.

.3 ASTM A240 – Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels for General Applications.

.4 ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

.5 ASTM C195 - Mineral Fibre Thermal Insulating Cement.

.6 ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.

.7 ASTM C449/C449M - Mineral Fibre Hydraulic-setting Thermal Insulating and Finishing Cement.

.8 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.

.9 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.

.10 ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

.11 ASTM C547 - Mineral Fibre Pipe Insulation.

.12 ASTM C552 - Cellular Glass Thermal Insulation.

.13 ASTM C553 – Mineral Fibre Blanket Thermal Insulation for Commercial and Industrial Applications.

.14 ASTM C578 - Rigid, Cellular Polystyrene Thermal Insulation.

.15 ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).

.16 ASTM C591 - Unfaced Preformed Cellular Polyisocyanurate Thermal Insulation.

.17 ASTM C592: Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).

.18 ASTM C610 - Moulded Expanded Perlite Block and Pipe Thermal Insulation.

.19 ASTM C612: Mineral Fiber Block and Board Thermal Insulation.

.20 ASTM C916: Adhesives for Duct Thermal Insulation.

.21 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.

.22 ASTM C1126: Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.

.23 ASTM C1136: Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

.24 ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.

.25 ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).

.26 ASTM D2842 - Water Absorption of Rigid Cellular Plastics.

.27 ASTM E84 - Surface Burning Characteristics of Building Materials.

.28 ASTM E96 - Water Vapour Transmission of Materials.

.29 NFPA 255 - Surface Burning Characteristics of Building Materials.

.30 UL 723 - Surface Burning Characteristics of Building Materials.

.31 NAIMA - North American Insulation Manufacturers Association.

.32 CAN/CG5B-51.11 Mineral Fibre Thermal Insulation Blanket.

.33 CAN/CG5B-51-GP-52 Ma Vapour Barrier, Jacket & Facing Material For Pipe Duct & Equipment Thermal Insulation.

.34 CAN/CG5B-51-GP-53 M Jacketing, Polyvinyl Chloride Sheet for Insulating Pipes, Vessels of Round Ducts

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

1.5 Quality assurance

.1 Materials: Flame spread/smoke developed rating of 25/50 or less to ULC S102 and ASTM E84.

1.6 Qualifications

.1 Applicator: Company specializing in performing the work of this section with minimum three (3) years experience.

1.7 Delivery, storage and handling

.1 All material shall be transported, shipped, stored, handled and installed in such a manner as not to degrade the quality, serviceability, or appearance. Material warranties shall not be voided by actions of the Contractor.

.2 Deliver materials to site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

.3 Store insulation in original wrapping and protect from weather and construction traffic.

.4 Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 Shop drawings

.1 Product Data: Provide product description, list of materials and thickness for each service, and locations.

.2 Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.9 Environmental requirements

.1 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

.2 Maintain temperature during and after installation for minimum period of twenty (24) hours.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Packaging and labelling: Every package or standard container of insulation, jackets, cements, adhesives, and coatings delivered to project site shall have the manufacturer’s stamp or label attached giving the name of the manufacturer, brand and description of material. Insulation materials shall be asbestos-free.

.2 Surface burning characteristics: Materials shall have a flame-spread rating of not more than twenty five (25) and a smoke-developed rating of not more than fifty (50), when tested in accordance with NFPA 255, ASTM E84 or UL 723. Insulation materials located exterior to the building perimeter are not required to be fire-rated.

2.3 Glass fibre, flexible

.1 Resin bonded fibrous glass blanket with a damage-resistant, flame retardant, reinforced aluminum foil facing. Owens Corning SOFTR Duct Wrap insulation or approved alternate. Duct Wrap Insulation: ASTM C1290, Type III, to a maximum service temperature of 250 °F (121 °C), and ASTM C1136, Type II, facing material. Provide the following:

.1 Type 75: 0.75 lb./ft.^{3} (12 kg/m^3) density: 1½ in., 2 in., 2.2 in. or 3 in. (38 mm, 51 mm, 56 mm or 76 mm) thickness.

.2 Type 100: 1.0 lb./ft.^{3} (16 kg/m^3) density: 1½ in. or 2 in. (38 mm or 51 mm) thick, or

.3 Type 150: 1.5 lb./cu.ft. (24 kg/m^3) density: 1½ in. or 2 in. (38 mm or 51 mm) thick.

.2 The duct wrap insulation shall consist of a blanket of glass fibers factory-laminated to a foil reinforced kraft (FRK) vapor retarder facing with a 2 in. (50 mm) (min.) stapling and taping flange on one edge.

.3 Other acceptable manufacturers offering equivalent products:

.1 Manson Insulation;

.2 Knauf Insulation Inc.;

.3 Johns Manville; or

.4 Approved alternate.

.4 Insulation: ASTM C553; flexible, non-combustible blanket.

.1 'k' value : ASTM C518,0.27, 0.25 and 0.23 at 75 °F (24 °C).

.2 Maximum moisture absorption: 0.20 % by volume.

.5 Vapour Barrier Jacket:

.1 Kraft paper with glass fibre yarn and bonded to aluminized film.

.2 Moisture vapour transmission: ASTM E96; 0.02 perm.

.3 Secure with pressure sensitive tape.

.6 Vapour Barrier Tape: Kraft paper reinforced with glass fibre yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

.7 Outdoor Vapour Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black colour.

.8 Tie Wire: Annealed steel, 1/16 in. (1.5 mm).

2.4 Mineral wool, flexible

.1 Blanket mineral fibre type roll form insulation, 1.5 lbs/ft.^{3} (24.0 kg/m^3) density, 38 mm (1½ in.) thick, with a factory applied vapour barrier facing. Johns Manville Duct Wrap Type 150 "Microlite" or approved alternate.

.2 Other acceptable manufacturers offering equivalent products:

.1 Knauf Insulation Inc.;

.2 Manson Insulation Products Ltd.; or

.3 Approved alternate.

2.5 Elastomeric insulation

.1 Acceptable Manufacturers:

.1 Armacell AP Armaflex;

.2 APArmaflex SA;

.3 ArmaTuff laminated Sheets and Rolls; or

.4 Approved alternate.

.2 Insulation material shall be a flexible, closed-cell elastomeric insulation in tubular or sheet form to ASTM C 534, "Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form."

.3 Insulation materials shall have a closed-cell structure to prevent moisture from wicking.

.4 Insulation material shall be manufactured without the use of CFC's, HFC's or HCFC's formaldehyde free, low VOC's, fibre free, dust free and shall resist mould and mildew.

.5 Materials shall have a flame spread index of less than twenty five (25) and a smoke-developed index of less than fifty (50) when tested in accordance with ULC S102, ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.

.6 Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft.^{2}-°F at a 75 °F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.

.7 Materials shall have a maximum water vapour transmission of 0.08perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.

.8 The material shall be manufactured under an independent third party supervision testing program covering the properties of fire performance, thermal conductivity and water vapour transmission.

2.6 Jackets

.1 Canvas Jacket: UL listed.

.1 Fabric: ASTM C921, 220 g/m^2, plain weave cotton treated with dilute fire retardant lagging adhesive.

.2 Lagging Adhesive: Compatible with insulation.

.2 Mineral Fibre (Outdoor) Jacket: Asphalt impregnated and coated sheet, 2.45 kg/m^2.

.3 PVC Plastic

.1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material.

.2 Minimum Service Temperature: -31 °F (-35 °C).

.3 Maximum Service Temperature: 151 °F (66 °C).

.4 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.

.5 Maximum Flame Spread: ASTM E84; 25 or less.

.6 Maximum Smoke Developed: ASTM E84; 50 or less.

.7 Thickness: 20 mil (0.5 mm) minimum.

.8 Colour: standard off-white.

.9 Covering Adhesive Mastic: Compatible with insulation, maximum VOC content of 50 g/L.

.10 Manufacturer:

.1 Johns Manville Ceel-Co 300 series;

.2 Speedline Smoke Safe;

.3 Proto Corp.; or

.4 Approved alternate.

2.7 Accessories

.1 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 20 05 00 – Common Mechanical Work Results. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.

.2 Vapour retarder lap adhesive shall be water based, and fire retardant.

.3 Tapes shall be of cloth reinforced aluminum, soft adhesive with minimum 2 in. (50 mm) width.

.4 Tie wire shall be of 1/16 in. (1.5 mm) ø stainless steel.

.5 Fasteners shall be of ⅛ in. (4 mm) diameter pins, with 1½ in. (38 mm) square clips. Clip pin length to suit insulation thickness.

.6 Bands shall be ½ in. (13 mm) wide ¼ in. (6 mm) thick galvanized steel.

.7 Facing shall be of 1 in. (25 mm) galvanized steel hexagonal wire mesh attached on both faces of insulation.

3 Execution

3.1 General

.1 Do not insulate:

.1 Factory pre-insulated equipment,

.2 Access plates,

.3 ASME stamps, and

.4 Manufacturer’s nameplates.

3.2 Examination

.1 Verify that components to be insulated are complete and tested before applying insulation materials.

.2 Apply insulation after the required tests have been completed and approved by the Consultant.

.3 Verify that surfaces are clean, foreign material removed, and dry.

3.3 Installation

.1 Install insulations to TIAC National Installation Standards.

.2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer's written instructions and as specified.

.3 On exposed equipment to be thermally insulated cover seams in least visible locations.

.4 Apply insulation close to equipment by grooving, scoring, and bevelling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

.5 Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapour barrier cement.

.6 Insulated equipment containing fluids below ambient temperature, insulate entire system.

.7 Fibre glass insulated equipment containing fluids below ambient temperature: Provide vapour barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapour barrier adhesive.

.8 For hot equipment containing fluids 140 °F (60 °C) or less, do not insulate flanges and unions, but bevel and seal ends of insulation.

.9 For hot equipment containing fluids over 140 °F (60 °C), insulate flanges and unions with removable sections and jackets.

.10 Fibre glass insulated equipment containing fluids above ambient temperature: Provide standard jackets, with or without vapour barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.

.11 Inserts and Shields:

.1 Application: Equipment 1½ in. (38 mm) diameter or larger.

.2 Shields: Galvanized steel between hangers and inserts.

.3 Insert location: Between support shield and equipment and under the finish jacket.

.4 Insert configuration: Minimum 6 in. (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.

.5 Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

.12 Finish insulation at supports, protrusions, and interruptions.

.13 Equipment in mechanical equipment rooms or finished spaces shall be finished with PVC jacket.

.14 Cover glass fibre insulation with metal mesh and finish with heavy coat of insulating cement.

.15 Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.

.16 Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

3.4 Tolerance

.1 Substituted insulation materials: Thermal resistance within 10% at normal conditions, as materials indicated.

3.5 Equipment insulation

.1 Insulate equipment as follows:

Mineral Fibre – Hot Surfaces 20 °C to 400 °C	**Thickness ins (mm)**
Heating glycol pumps along with fittings and accessories	2 (50)
Expansion tanks, air separators	2 (50)
Heat exchangers	2 (50)
Any other equipment operating at a high temperature	2 (50)
Hot water storage tank	1½ (38)
Flexible Elastomeric Unicellular Sheet – Cold Surfaces	**Thickness ins (mm)**
Chilled water pumps, fittings and accessories	1½ (38)
Evaporators, coolers, compressors	1½ (38)
Expansion tanks and air separators	1½ (38)
Roof drain sumps	1½ (38)
Water meters	1½ (38)
Water closet carriers	1½ (38)
Strainer heads in cold piping	2 (50)
Any other equipment operating at low temperature	1½ (38)
Rigid Mineral Wool – Cold Surfaces	
Chilled water storage tank	1½ in. (38)

End of section

1 General

1.1 Section includes

.1 Piping insulation

.2 Jackets

.3 Accessories

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 Refer to the latest edition of the following:

.1 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

.2 ASTM A167 – Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet and Strip.

.3 ASTM A240 – Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels for General Applications.

.4 ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

.5 ASTM C195 - Mineral Fibre Thermal Insulating Cement.

.6 ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.

.7 ASTM C449/C449M - Mineral Fibre Hydraulic-setting Thermal Insulating and Finishing Cement.

.8 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Metre Apparatus.

.9 ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.

.10 ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.

.11 ASTM C547 - Mineral Fibre Pipe Insulation.

.12 ASTM C552 - Cellular Glass Thermal Insulation.

.13 ASTM C553 – Mineral Fibre Blanket Thermal Insulation for Commercial and Industrial Applications.

.14 ASTM C578 - Rigid, Cellular Polystyrene Thermal Insulation.

.15 ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).

.16 ASTM C591 - Unfaced Preformed Cellular Polyisocyanurate Thermal Insulation.

.17 ASTM C592: Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).

.18 ASTM C610 - Moulded Expanded Perlite Block and Pipe Thermal Insulation.

.19 ASTM C612: Mineral Fiber Block and Board Thermal Insulation.

.20 ASTM C916: Adhesives for Duct Thermal Insulation.

.21 ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.

.22 ASTM C1126: Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation.

.23 ASTM C1136: Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

.24 ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.

.25 ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).

.26 ASTM D2842 - Water Absorption of Rigid Cellular Plastics.

.27 ASTM E84 - Surface Burning Characteristics of Building Materials.

.28 ASTM E96 - Water Vapour Transmission of Materials.

.29 NFPA 255 - Surface Burning Characteristics of Building Materials.

.30 UL 723 - Surface Burning Characteristics of Building Materials.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Provide product description, list of materials and thickness for each service, and locations

.4 Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.5 Quality assurance

.1 Materials: Flame spread/smoke developed rating of 25/50 or less to ULC S102 and ASTM E84.

1.6 Qualifications

.1 Applicator: Company specializing in performing the work of this section with minimum three (3) years experience.

1.7 Delivery, storage and handling

.1 All material shall be transported, shipped, stored, handled and installed in such a manner as not to degrade the quality, serviceability, or appearance. Material warranties shall not be voided by actions of the Contractor.

.2 Deliver materials to site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

.3 Store insulation in original wrapping and protect from weather and construction traffic.

.4 Protect insulation against dirt, water, chemical, and mechanical damage.

1.8 Environmental requirements

.1 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

.2 Maintain temperature during and after installation for minimum period of twenty four (24) hours.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Packaging and labelling: Every package or standard container of insulation, jackets, cements, adhesives, and coatings delivered to project site shall have the manufacturer's stamp or label attached giving the name of the manufacturer, brand and description of material. Insulation materials shall be asbestos-free.

.2 Surface burning characteristics: Materials shall have a flame-spread rating of not more than twenty five (25) and a smoke-developed rating of not more than fifty (50), when tested in accordance with NFPA 255, ASTM E84 or UL 723. Insulation materials located exterior to the building perimeter are not required to be fire-rated.

2.3 Glass fibre

.1 Molded Fibrous Glass Pipe Insulation: Comply with ASTM C547, Type I, Grade A; and Type IV, Grade B; and ASTM C585, for sizes required and of a type suitable for installation on piping systems as required:

.1 For indoor systems operating at temperatures from 0 °F (-18 °C) to +850 °F (454 °C), no heat-up schedule required: Owens Corning SSL II with ASJ Max FIBERGLAS Pipe Insulation or approved alternate.

.2 For systems operating at temperatures +850 °F (232 °C) to 1,000 °F (535 °C), heat-up schedule required: Owens Corning SSL II with ASJ Max FIBERGLAS Pipe Insulation or approved alternate.

.2 Other acceptable manufacturers offering equivalent products:

.1 Manson Insulation;

.2 Knauf Insulation Inc.;

.3 Johns Manville; or

.4 Approved alternate.

.3 Insulation: ASTM C547; rigid moulded, non-combustible.

.1 'k' value : ASTM C335, 0.26 at 75 °F (24 °C).

.2 Operating Temperature Range: 0 °F (-17 °C) to 1,000 °F (537 °C).

.3 Jacket temperature Range: -20 °F (-29 °C) to 150 °F (66 °C).

.4 Maximum Moisture Absorption: <5 % by weight.

.4 Vapour Barrier Jacket

.1 ASTM C921, White kraft paper reinforced with glass fibre yarn and bonded to aluminized film.

.2 Moisture Vapour Transmission: ASTM E96; 0.01 perm.

.3 Secure with self-sealing longitudinal laps and butt strips.

.4 Secure with outward clinch expanding staples and vapour barrier mastic.

.5 Tie Wire: 1.3mm stainless steel with twisted ends on maximum 12 in. (300 mm) centres.

.6 Vapour Barrier Lap Adhesive: Compatible with insulation.

.7 Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

.8 Fibrous Glass Fabric

.1 Cloth: Untreated; 9 oz/yd^2 (305 g/m^2) weight.

.2 Blanket: 1.0 lb/ft.^{3} (16 kg/cu m) density.

.9 Indoor Vapour Barrier Finish: Vinyl emulsion type acrylic, compatible with insulation, white colour.

.10 Outdoor Vapour Barrier Mastic: Vinyl emulsion type acrylic, compatible with insulation, white colour.

.11 Insulating Cement: ASTM C449.

2.4 Cellular glass (underground)

.1 Insulation shall be Owens Corning FOAMGLAS or approved alternate, manufactured in accordance with ASTM C 552, “Standard Specification

for Cellular Glass Thermal Insulation". Insulation shall be fabricated in half sections wherever possible. For large diameter piping where half sections are not practical, curved sidewall segments are preferred.

.2 Joint Sealant: PITTSEAL 444N or PITTSEAL 727 or approved alternate.

.3 Vapor Retarder Mastic: PITTCOTE 300 Finish, an asphalt cutback mastic; or approved alternate.

.4 Protection Wrap: PITTWRAP CW30 Jacketing, a self-sealing, non-metallic, bituminous sheet; or approved alternate.

.5 Weather Barrier Mastic: PITTCOTE 404 Coating, an acrylic latex mastic; or approved alternate.

.6 Reinforcing Fabric: PC Fabric 79, a polyester fabric mesh; or approved alternate.

.7 Insulation Adhesive: PC 88 Adhesive, a two (2) component urethane modified asphalt adhesive; or approved alternate.

.8 Fabrication Adhesive: Hydrocal B-11 Powder, gypsum cement or StrataFab Adhesive; or approved alternate.

.9 High Temperature Insulation Adhesive/Sealant: Check product data sheets for temperature limits.

.10 Tape: 1 in. (25 mm) wide, high tensile strength, fiber reinforced, strapping tape. Scotch Brand Filament Tape or approved alternate. Tape is appropriate for providing temporary insulation securement for piping with insulation O.D.'s 18 in. (457 mm) or smaller as long as it is covered with metal jacket afterwards. Tape is not acceptable as primary means of securement if the insulation system is being designed to provide fire protection.

.11 Bore Coating:

.1 Hydrocal B-11gypsum cement or approved alternate for service temperatures above 150 °F (66 °C) to and below -290 °F (-179 °C).

.2 PC 136 is a reactive cementitious product manufactured by Anti Hydro International or approved alternate, for service temperatures of -100 °F (-73 °C) to 900 °F (482 °C).

2.5 Elastomeric Insulation

.1 Acceptable Manufacturers:

.1 AP ArmaFlex White LapSeal;

.2 AP ArmaFlex Black LapSeal;

.3 AP ArmaFlex Tubes; or

.4 Approved alternate.

.2 Insulation material shall be a flexible, closed-cell elastomeric insulation in tubular form to ASTM C534, "Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form."

.3 Insulation materials shall have a closed-cell structure to prevent moisture from wicking.

.4 Insulation material shall be manufactured without the use of CFC's, HFC's or HCFC's formaldehyde free, low VOC's, fibre free, dust free and shall resist mould and mildew.

.5 Materials shall have a flame spread index of less than twenty five (25) and a smoke-developed index of less than fifty (50) when tested in accordance with ULC S102, ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.

.6 Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft.^{2}-°F at a 75 °F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.

.7 Materials shall have a maximum water vapour transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.

.8 The material shall be manufactured under an independent third party supervision testing program covering the properties of fire performance, thermal conductivity and water vapour transmission.

.9 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 20 05 00 – Common Mechanical Work Results. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.

2.6 Jackets

.1 Canvas Jacket: UL listed.

.1 Fabric: ASTM C921, 220 g/sq m, plain weave cotton treated with dilute fire retardant lagging adhesive.

.2 Lagging Adhesive: Compatible with insulation.

.2 PVC Plastic

.1 Jacket: ASTM C921, One piece moulded type fitting covers and sheet material.

.1 Minimum Service Temperature: -31 °F (-35 °C).

.2 Maximum Service Temperature: 151 °F (66 °C).

.3 Moisture Vapour Transmission: ASTM E96; 0.03 perm inches.

.4 Maximum Flame Spread: ASTM E84; twenty five (25) or less.

.5 Maximum Smoke Developed: ASTM E84; fifty (50) or less.

.6 Thickness: 20 mil (0.5 mm) minimum.

.2 Colour: standard off-white.

.3 Covering Adhesive Mastic: Compatible with insulation, maximum VOC content of 50 g/L.

.4 Manufacturer:

.1 Johns Manville Ceel-Co 300 series;

.2 Speedline Smoke Safe;

.3 Proto Corp.; or

.4 Approved alternate.

.3 Aluminum Jacket: ASTM B209.

.1 Thickness: 0.02 in. (0.40 mm) sheet with factory applied polyethylene and kraft paper moisture barrier on inside surface.

.2 Finish: Smooth surface for jacket outside diameters of 8 in. (200 mm) or less. Embossed surface for jacket outside diameters of 10 in. (250 mm and larger).

.3 Joining: Longitudinal slip joints and 2 in. (50 mm) laps.

.4 Fittings: 0.02 in. (0.40 mm) thick die shaped fitting covers with factory attached protective liner.

.5 Bands: ⅜ in. (9.5 mm) wide; 24 gauge aluminum.

2.7 Accessories

.1 Adhesives and finishes shall be as recommended by the insulation manufacturer and shall comply with Section 20 05 00 – Common Mechanical Work Results. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings specified.

.2 Vapour retarder lap adhesive shall be water based, fire retardant.

.3 Tapes shall be of cloth reinforced aluminum, soft adhesive with minimum 2 in. (50 mm) width.

.4 Tie wire shall be of 1/16 in. (1.5 mm) ø stainless steel.

.5 Fasteners shall be of ⅛ in. (4 mm) Ø pins, with 35 mm square clips. Clip length to suit insulation thickness.

.6 Bands shall be ½ in. (12 mm) wide ¼ in. (6 mm) thick galvanized steel.

.7 Facing shall be of 1 in. (25 mm) galvanized steel hexagonal wire mesh attached on both faces of insulation.

2.8 Lavatory kits

.1 Flexible seamless moulded closed cell PVC resin, formulated with anti-microbial additive to limit the growth of fungi and bacteria to protect against heat and contusions.

.1 McGuire PROWRAP to suit each application.

.1 Acceptable alternates: IPS Corp., Truebro LavGuard, TCI Skal-Gard and Johns Manville Zeston Snap-Trap; or

.2 Other approved alternate.

3 Execution

3.1 General

.1 Do not insulate the following:

.1 Unions,

.2 Cleanouts and hand holes,

.3 Chrome plated pipe work, and

.4 Flexible connections.

3.2 Examination

.1 Verify that piping has been tested before applying insulation materials.

.2 Apply insulation after the required tests have been completed and approved by the Consultant.

.3 Verify that surfaces are clean, foreign material removed, and dry.

3.3 Installation

.1 Install piping insulations to TIAC National Installation Standards.

.2 Apply insulation materials, accessories, jackets and finishes in accordance with manufacturer's written instructions and as specified.

.3 On exposed piping, locate insulation and cover seams in least visible locations.

.4 Insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature:

.1 Provide vapour barrier jackets, factory applied or field applied.

.2 Insulate fittings, joints, and valves with moulded insulation of like material and thickness as adjacent pipe.

.3 Finish with glass cloth and vapour barrier adhesive.

.4 PVC fitting covers shall be used.

.5 Insulation shall be continuous through walls, sleeves, pipe hangers, and other pipe penetrations.

.6 Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.

.5 For insulated pipes conveying fluids above ambient temperature:

.1 Provide standard jackets, with or without vapour barrier, factory applied or field applied.

.2 Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.

.3 Finish with glass cloth and adhesive.

.4 PVC fitting covers shall be used.

.5 For hot piping conveying fluids 140 °F (60 °C) or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

.6 For hot piping conveying fluids over 140 °F (60 °C), insulate flanges and unions at equipment.

.6 Inserts and Shields:

.1 Application: Piping 1½ in. (40 mm) diameter or larger.

.2 Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.

.3 Insert Location: Between support shield and piping and under the finish jacket.

.4 Insert Configuration: Minimum 6 in. (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.

.5 Insert Material: hydrous calcium silicate insulation.

.7 Finish insulation at supports, protrusions, and interruptions.

.8 For pipe exposed in finished spaces, finish with canvas jacket sized for finish painting. Piping exposed in mechanical rooms, finish with PVC jacket.

.9 For exterior applications, provide vapour barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapour barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping. All seams shall be sealed weathertight.

.10 For buried piping, provide factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with 1.0 mil (0.025 mm) thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.

.11 For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping. All seams shall be sealed weathertight.

3.4 Tolerance

.1 Substituted insulation materials: Thermal resistance within 10 % at normal conditions, as materials indicated.

3.5 Pipe insulation

.1 Insulate piping as follows:

Service	Operating Temperature Range °F (°C)	Pipe Diameter ins. (mm)	Insulation Thickness ins. (mm)
Chilled Water & Glycol Supply and Return	40 – 55 (4 – 13)	All sizes	1-1/2 (38)
All piping outside of building or in unheated spaces	0 to 850 (-18 to 454)	All sizes	2 (50)
Condensate (cold)	0 to 850 (-18 to 454)	All sizes	1 (25)
Potable Cold Water	0 to 850 (-18 to 454)	All sizes	1 (25)
Potable Hot Water and Recirculation	>105 (41)	< 2 (50)	1 (25)
		> 2-1/2 (65)	1-1/2 (38)
Hot Water and Glycol Supply and Return	105 to 140 (41 to 60)	< 4 (100)	1 (25)
		> 6 (125)	1-1/2 (38)
	141 to 200 (61 to 93)	All sizes	1-1/2 (38)
Non-Potable Water	0 to 850 (-18 to 454)	All sizes	1 (25)
Sanitary Drainage (horizontal only)	40 to 55 (4 to 13)	All sizes	1 (25)

Service	Operating Temperature Range °F (°C)	Pipe Diameter ins. (mm)	Insulation Thickness ins. (mm)
Steam Humidifier	201 to 250 (94 to 121)	< 2 (50)	1-1/2 (38)
		2-1/2 to 6 (65 to 150)	2 (50)
Storm Drainage (horizontal only)	40 to 55 (4 to 13)	All sizes	1 (25)

.2 Insulate fittings and flanges and pipe connections with insulated fitting covers.

.3 Wrap butt joints with a 4 in. (100 mm) strip of fire resistant vapour barrier jacket cemented with lagging adhesive.

.4 Where the pipe hanger is around the insulation, provide an insulation protection shield within the pipe saddle. Coordinate with installation of hangers.

.5 Insulate all fittings, flanges and valves on pipes to provide equivalent insulation to that of adjoining pipe.

.6 Continue insulation through sleeves including specified finish.

.7 Cut back covering on strainers and finish off to expose removable head insulation.

.8 Cover expansion joints first with 24 gauge (0.7 mm) galvanized metal sleeve and then insulate to provide equivalent thickness to that on adjoining pipe.

.9 Protect insulation with protection saddles where insulated pipe is supported by rollers.

.10 Insulate pipe hangers supporting piping carrying water at 70 °F (21 °C) or less to prevent condensation. Extend insulating material along hanger rod to height four (4) times thickness of insulation. Seal insulation with vapour proof sealant.

.11 Extend pipe insulation and covering through walls, floors, ceilings, and concrete beams, unless indicated otherwise on drawings. Protect

exposed insulation extending through floors with 4 in. (100 mm) wide strip of 18 gauge (1.3 mm) galvanized iron.

.12 Pack annular space between pipe sleeves and piping or pipe covering with glass fibre insulation or rock-wool insulation. In fire rated assemblies use Dow Silicon RTV or other ULC listed approved alternate materials. Seal exposed insulation with mastic.

.13 Recover exposed surfaces of insulated piping installed in exposed areas, mechanical rooms, and equipment rooms with PVC jacketing and PVC fitting covers installed in accordance with manufacturer's instructions.

.14 Insulate and cover exposed surfaces of waste connections, traps, hot and cold supply risers and valves at each lavatory and sink designated for "barrier free" use with: PVC insulated fitting covers specifically designed for this application. Vinyl material is not to exceed flame spread rating of 150, and if intended to be used in high buildings, its smoke developed classification does not exceed 300.

.15 Provide aluminum metal jacketing on all exposed thermally insulated piping located outdoors and as indicated on the drawings.

3.6 Refrigerant pipe insulation

.1 Insulate all refrigerant suction and hot gas piping and fittings with flexible foamed plastic pipe insulation. Insulation shall fit pipe. Thickness shall be as follows: ½ in. (13 mm) thick for pipe 1 in. (25 mm) and smaller; ¾ in. (19 mm) thick for pipe 1¼ in. (32 mm) to 2 in. (50 mm); 1 in. (25 mm) thick for pipes 2½ in. (65 mm) and larger.

.2 Slip insulation on to tubing before tubing sections and fittings are assembled. Keep slitting of insulation to a minimum. Seal all joints in the insulation with Armaflex 520 BLV or approved alternate. Insulate flexible pipe connectors.

.3 On insulation exposed outside the building, place "slit" joint seams on bottom of pipe and provide two (2) coats of grey Armaflex finish or approved alternate. Extend insulation through pipe support clamps. Provide a 6 in. (150 mm) long, 20 gauge (1.1 mm) galvanized steel sleeve around pipe insulation at each support.

3.7 Underground insulation

.1 Install insulation underground where and as indicated and in accordance with manufacturer's recommended installation instructions.

.2 All piping shall be cleaned of foreign substances and free of surface moisture prior to and during application of insulation and coverings.

.3 Ensure that all weld beads are ground smooth with the surface of the pipe prior to application of the insulation.

.4 Insulation thickness:

Service	Thickness
Low temp heat recovery	1 in. (25 mm)
Chilled water	1 in. (25 mm)

.5 Preparation:

.1 After the nominal system diameter is determined (pipe diameter plus insulation thickness), the trench shall be excavated to allow 6 in. (150 mm) minimum clearance in all directions around the final system.

.2 The bottom of the trench shall be graded to the design slope of the piping and to provide uniform bearing along its entire length. Where wet or unstable soils are encountered, such soil shall be removed to a sufficient depth and the trench backfilled with coarse sand or loose granular earth.

.3 This backfill shall be compacted to a density equal to that of the acceptable portions of the trench where excavation of rock is required, the rock shall be excavated to an over depth of 6 in. (150 mm) minimum below the specified trench depth. Over depths in rock shall be backfilled with loose granular earth or coarse sand and thoroughly tamped.

.4 In areas of high water table, adequate drainage shall be provided by a gravel bed and a perforated drain pipe covered with synthetic drainage fabric to prevent clogging. The pipe shall lead to a sump provided with means to remove water from the trench area.

.5 All insulated piping shall rest in a 6 in. (150 mm) layer of compacted sand. Excavation shall be kept free of standing water during insulation and jacketing application.

.6 Where excessive or cyclical movement is anticipated, the bore of FOAMGLAS insulation, or approved alternate, shall be coated with a thin application of bore coating and allowed to dry before insulation is applied to the pipe.

.6 Insulation Application:

.1 Insulation and jacketing shall be applied to piping in 10 ft. (3 m) segments (maximum length). After completion, the segments are rotated 180 ° and the bottom of the jacketing and butt strips are inspected for proper application and sealing. If any defects are visible, they must be corrected. Major defects may require removal of jacketing. Assuming proper jacketing and sealing, the segments are rotated back into position and the connecting butt strips are applied.

.1 Field jacketed insulation - staggered joints: The last section of pipe covering the 10 ft. (3 m) segment is cut even to form a through joint between completed segments.

.2 Large diameter piping: shorter segments can be insulated and jacketed if more practical.

.3 Abrasion: Insulation sections for large diameter piping will have to be bore coated.

.4 Special considerations - anchors, guides, expansion loops, elbows, etc.: The completed insulated segment is rotated and inspected before installing the connecting section of insulation at the anchors, guides, expansion loops, elbows, etc. These procedures are not to be used on oversized insulation.

.2 Field-Jacketed: Field-jacketed insulation shall be applied to the piping with butt joints staggered and tightly butted. Longitudinal and butt joints shall be left dry. All joints shall be tightly fitted to eliminate voids by refitting or replacing sections of insulation. Each section of insulation shall be held in place by two (2) wraps of strapping tape with a 50 % overlap per wrap. For double-layer

applications, the second layer of insulation shall be applied in a manner similar to the first, with all joints staggered between layers.

.3 Factory-Jacketed: Insulation which has been pre-jacketed with jacketing shall be applied joint-to-joint with all joints tightly butted. Strapping staples may be used over the jacketing to temporarily secure the insulation until longitudinal laps are sealed and butt strips applied.

.4 Pre-Insulation of Pipe: Where conditions permit, insulation and jacketing may be applied outside of the trench to sections of piping. Pipe lengths should be insulated in segments. Length of insulation segment should not exceed 10 ft. (3 m). Leave un-insulated spaces between segments to allow for placement of slings by which the pipe can be lowered into the trench. The use of a spreader bar with two slings or more is recommended. The quantity and location of sling placement shall be determined by the design professional to avoid excessive deflection, and facilitate proper control of the pipe length during transfer. After the sections of pipe are in place in the trench, and ends of the sections secured, insulation and jacketing shall be applied to the joint areas and un-insulated spaces that were not completed above ground. Adequate working space should be maintained for installation personnel.

.7 Jacketing Application:

.1 Apply the specified jacketing in strict accordance with the appropriate product data sheet. Seal all overlaps and butt strips as noted in the product data sheet to ensure that ground water cannot penetrate the jacket system.

.2 In tunnels, manholes and pre-cast trenches where high ambient temperatures may exist, metal bands should be installed 12 in. (300 mm) on centre of the jacketing exterior to control slippage of the overlap seal.

.3 Irregular Surfaces:

.1 At all irregular surfaces such as elbows, tees, fitting covers, etc., the jacketing shall be pre-cut to fit the contour of the surface to which it is to be applied. Pre-cut sections shall allow for 2 in. (50 mm) overlap. All laps shall be sealed. In

addition to sealing the jacketing on these irregular surfaces, a glove coat of the coating shall be applied over the jacketing. First, carefully burn away the exterior plastic film on the jacketing. Then apply a glove coat. While still tacky, embed a layer of reinforcing fabric in the coating. After one hour, apply a second coat over the first coat. Total wet film thickness of the two (2) coats should be ⅛ in. (3 mm) minimum.

.2 As an alternative to the cutting and fitting of the jacketing on fittings, a five-layer application may be used. The coating shall be applied in accordance with the manufacturer's recommendations, in alternating layers of mastic, reinforcing fabric, mastic, mastic fabric and mastic, totalling five layers. Total wet film thickness shall be ¼ in. (6 mm) minimum.

.3 If backfilling takes place less than twenty four (24) hours after the coating is applied, roofing felt shall be placed over the coating before backfilling.

.4 Ends and bore of insulation left exposed at day's end shall be sealed between the insulation and the pipe to prevent bulk water entry.

.5 All completed work shall be backfilled as soon as possible to prevent damage to the insulation system.

.8 Field Quality Control: After application of the jacketing system to all straight and irregular sections of insulation, visually inspect all laps, seams, butt strips and glove-coated areas to ensure that these areas are sealed from water entry in accordance with the specifications and appropriate product data sheets.

.9 Backfilling: The trench shall be carefully backfilled using the excavated earth approved for backfilling, consisting of sand, clay, earth, loam or other approved materials. Sand backfill shall be placed within 6 in. (150 mm) of the insulated pipe and shall be free of rocks, debris or stones greater than ¼ in. (6 mm) diameter. Care shall be taken not to damage jacketing during backfilling. Backfill shall be applied in 6 in. (150 mm) lifts, tamping each lift until a depth of 1 ft. (300 mm) over the insulated pipe is

reached. The remainder of the trench shall be backfilled in 1 ft. (300 mm) lifts, with each lift tamped to the desired compaction.

End of section

1 General

1.1 Section includes

.1 Pipe, pipe fittings, valves, and connections for piping systems.

.1 Storm drainage

.2 Sanitary drainage

.3 Sanitary vent

.4 Potable water

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

.2 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

.3 ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.

.4 ASME B16.26 - Copper Alloy Bronze Fittings for Flared Copper Tubes.

.5 ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV.

.6 ASME B16.32 - Cast Copper Alloy Solder Joint Fittings for Solvent Drainage Systems.

.7 ASTM A74 - Cast Iron Soil Pipe and Fittings.

.8 ASTM B32 - Solder Metal.

.9 ASTM B42 - Seamless Copper Pipe, Standard Sizes.

.10 ASTM B68 - Seamless Copper Tube, Bright Annealed.

.11 ASTM B75 - Seamless Copper Tube.

.12 ASTM B88 - Seamless Copper Water Tube.

.13 ASTM B251 - General Requirements for Wrought Seamless Copper and Copper-Alloy Tube.

.14 ASTM B302 – Thread-less Copper Pipe, Standard Sizes.

.15 ASTM B306 - Copper Drainage Tube (DWV).

.16 ASTM D2235 - Solvent Cement for Acrylonitrile - Butadiene - Styrene (ABS) Plastic Pipe and Fittings.

.17 ASTM D2239 - Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

.18 ASTM D2241 - Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

.19 ASTM D2447 - Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.

.20 ASTM D2466 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

.21 ASTM D2564 - Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.

.22 ASTM D2661 - Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings.

.23 ASTM D2665 - Polyvinyl Chloride (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.

.24 ASTM D2729 - Polyvinyl Chloride (PVC) Sewer Pipe and Fittings.

.25 ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer, Pipe, and Fittings.

.26 ASTM D2846 - Chlorinated Polyvinyl Chloride (CPVC) Pipe, Fittings, Solvent Cements and Adhesives for Potable Hot Water Systems.

.27 ASTM D2855 - Making Solvent-Cemented Joints with Polyvinyl Chloride (PVC) Pipe and Fittings.

.28 ASTM D3034 - Type PSM Polyvinyl Chloride (PVC) Sewer Pipe and Fittings.

.29 ASTM E814 - Fire Tests of Through-Penetration Fire Stops.

.30 ASTM F679 - Polyvinyl Chloride (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.

.31 ASTM F708 - Design and Installation of Rigid Pipe Hangers.

.32 AWWA C110 - Ductile - Iron and Gray - Iron Fittings, 3 in. - 48 in. (75mm - 1200mm), for Water.

.33 AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

.34 AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.

.35 AWWA C651 - Disinfecting Water Mains.

.36 CISPI 301 - Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications.

.37 CISPI 310 - Joints with Hub-less Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.

.38 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.

.39 MSS SP69 - Pipe Hangers and Supports - Selection and Application.

.40 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit a ‘Letter of Conformance’, indicating specified items selected for use in the project with the following supporting product data and reports.

.4 Provide data on valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.

.5 Record actual locations of valves.

1.5 Quality assurance

.1 Perform Work to Province of Ontario standards. Maintain one (1) copy on site.

.2 Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.6 Regulatory requirements

.1 Perform Work to Province of Ontario plumbing code.

.2 Conform to applicable code for installation of backflow prevention devices.

.3 Provide certificate of compliance from authority having jurisdiction indicating approval of installation of backflow prevention devices.

1.7 Delivery, storage and protection

.1 Accept valves on site in shipping containers with labelling in place. Inspect for damage.

.2 Provide temporary protective coating on cast iron and steel valves.

.3 Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

.4 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.8 Environmental requirements

.1 Do not install underground piping when bedding is wet or frozen.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Sanitary waste and vent piping - buried

.1 Sizes up to 2½ in. (65 mm).

.1 ABS-DWV pipe ASTM D2751 or ASTM F628 with ABS fittings and solvent welded (ASTM D2235) joints.

.2 PVC-DWV pipe to CSA B181.2 with PVC fittings and solvent welded joints.

.2 Sizes 3 in. (75 mm) and larger.

.1 ABS-DWV pipe ASTM D2751 or ASTM F628 with ABS fittings and solvent welded (ASTM D2235) joints.

.2 PVC-DWV pipe to CSA B181.2 with PVC fittings and solvent welded joints.

2.3 Sanitary waste and vent piping - aboveground

.1 Sizes up to 2½ in. (65 mm).

.1 Copper tube ASTM B306, DWV seamless copper tube with cast bronze (ASME B16.23) or wrought copper (ASME B16.29) fittings and 95/5 soldered joints (ASTM B32). Excluding fixture drain connections.

.2 Sizes 3 in. (75 mm) and larger.

.1 Cast iron soil pipe (CISPI 301) hub-less with cast iron fittings and joints (CISPI 310) with neoprene gasket, stainless steel clamp and shield.

2.4 Storm drainage piping – buried

.1 Sizes 3 in. (75 mm) and larger.

.1 ABS-DWV pipe ASTM D2751 or ASTM F628 with ABS fittings and solvent welded (ASTM D2235) joints.

.2 PVC-DWV pipe to CSA B181.2 with PVC fittings and solvent welded joints.

2.5 Storm drainage piping – aboveground

.1 Sizes 3 in. (75 mm) and larger.

.1 Cast iron soil pipe (CISPI 301) hub-less with cast iron fittings and joints (CISPI 310) with neoprene gasket, stainless steel clamp and shield.

2.6 Water piping - aboveground

.1 All Sizes.

.1 Type `L', ASTM B88 hard drawn copper tube with cast copper alloy (ASME B16.18) or wrought copper and bronze (ASME B16.22) fittings and couplings and 95/5 soldered joints.

2.7 Flanges, unions and couplings

.1 Pipe Size up to 3 in. (75 mm):

.1 Ferrous pipe: Class 150 psi (1,033 kPa) malleable iron threaded unions.

.2 Copper tube and pipe: Class 150 psi (1,033 kPa) bronze unions with soldered joints.

.2 Pipe Size over 4 in. (100 mm):

.1 Ferrous pipe: Class 150 psi (1,033 kPa) forged steel slip-on flanges; preformed 1/16 in. (1.5 mm) thick neoprene gaskets.

.2 Copper tube and pipe: Class 150 psi (1,033 kPa) slip-on bronze flanges; preformed 1/16 in. (1.5 mm) thick neoprene gaskets.

.3 Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.8 Valves – general

.1 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.

.2 Provide valves of the same manufacturer where possible.

.3 Manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.

.4 Valid CRN (Canadian Registration Number) issued by Province of Ontario required for each valve.

.5 Materials:

.1 Bronze: ASTM B62 or B61 as applicable

.2 Brass: ASTM B283 C3770

.3 Cast Iron: ASTM A126 Class B

.6 End Connections:

.1 Flanged ends: ANSI B16.1 (Class 125), ANSI B16.5

.2 Face-to-face dimensions: ANSI B16.10

.7 Design and Testing:

.1 Bronze Gate & Check valves: MSS-SP-80

.2 Ball Valves: MSS-SP-110

.3 Cast Iron Gate Valves: MSS-SP-70

.4 Cast Iron Globe Valves: MSS-SP-85

.5 Cast Iron Check: MSS-SP-71

.6 Butterfly Valves: MSS-SP-67

.7 First named product as indicated in paragraphs below; other acceptable manufacturers, subject to shop drawing review.

2.9 Isolation valves

.1 Sizes up to 50 mm (2 in.):

.1 Construction: MSS SP-110, 2 piece full port forged brass ball valve, cold working pressure 600 psig (4,140 kPa), threaded or soldered ends, PTFE seats, brass stem, chrome plated ball. Valves in insulated piping, provide a 2 in. (50 mm) stem extension and extended operating handle of non-thermal conductive material, and protective sleeve that allows operation of valve without breaking the vapour seal or disturbing insulation.

.2 Manufacturers: Subject to compliance with requirements, provide products by one of the following:

.1 Jenkins;

.2 Kitz Corporation;

.3 Watts Regulator; or

.4 Approved alternate.

.2 Sizes 65 mm (2½ in.) and larger:

.1 Construction: MSS SP-70, gate valve with rising stem, cold working pressure 200 psig (1,380 kPa), ASTM A126 gray iron body with

bolted bonnet and flanged ends, bronze trim, solid wedge disc and asbestos free packing and gasket.

.2 Manufacturers: Subject to compliance with requirements, provide products by one of the following:

.1 Jenkins;

.2 Kitz Corporation;

.3 Watts Regulator; or

.4 Approved alternate.

2.10 Balancing valves

.1 Sizes up to 50 mm (2 in.):

.1 Construction: MSS SP-80, cold working pressure 300 psig (2,070 kPa) with a bronze body with integral seat and union ring bonnet to ASTM B62, soldered or threaded ends, bronze stem, PTFE disc, asbestos free packing and either a malleable iron, bronze, or aluminium hand wheel.

.2 Manufacturers: Subject to compliance with requirements, provide products by one of the following:

.1 Jenkins;

.2 Kitz Corporation;

.3 Watts Regulator; or

.4 Approved alternate.

.2 Sizes 65 mm (2½ in.) and larger:

.1 Construction: MSS SP-85, cold working pressure 200 psig (1,380 kPa) with a gray iron body with a bolted bonnet to ASTM A126, flanged ends, bronze trim and an asbestos free packing and gasket.

.2 Manufacturers: Subject to compliance with requirements, provide products by one of the following:

.1 Jenkins;

.2 Kitz Corporation;

.3 Watts Regulator; or

.4 Approved alternate.

2.11 Check valves

.1 Sizes up to 50 mm (2 in.):

.1 Construction: MSS SP-80, cold working pressure 300 psig (2,070 kPa) with an ASTM B62 bronze body swing check with horizontal flow, threaded or soldered ends, and bronze disc.

.2 Manufacturers: Subject to compliance with requirements, provide products by one of the following:

.1 Jenkins;

.2 Watts Regulator; or

.3 Approved alternate.

.2 Sizes 65mm (2½ in.) and larger:

.1 Construction: MSS SP-71, cold working pressure 200 psig (1,380 kPa) with a gray iron body and bolted bonnet to ASTM A126 and a clear or full waterway design, flanged ends, composition trim, bronze seat ring and disc holder, PTFE disc and asbestos free gasket.

.2 Manufacturers: Subject to compliance with requirements, provide products by one of the following:

.1 Jenkins;

.2 Watts Regulator; or

.3 Approved alternate.

2.12 Drain valves

.1 Shut-off, for drips and drains, Crane/Jenkins model 901CJ or approved alternate complete with adaptor, 1,400 kPa (200 psi); cold working pressure, bronze body, hose outlet, and threaded inlet, complete with 658 cap and chain.

2.13 Pressure reducing valves

.1 Pressure reducing valves shall be 2,100 kPa (300 psig) rated, Watts Series 223 or approved alternate, all bronze body construction, screwed union/thread connection, complete with bronze `Y' type strainer with removable stainless screen. Unit shall feature built-in integral by-pass, threaded bell housing to body connection for field servicing, and shall

have set screw adjustment of integral spring connect to nylon reinforced Buna-n diaphragm assembly and piston type control.

.2 Each assembly shall have a field adjustable outlet pressure of 140 to 580 kPa (20 to 85 psig) with a variable inlet pressure of 550 to 2,050 kPa (80 to 300 psig).

.3 Each unit shall be factory set to provide an outlet system pressure of pressure of 450 kPa (65 psig).

.4 Alternates: Wilkins, Conbraco, Febco, or other approved alternate.

2.14 Relief valves

.1 ASME rated, Wilkins Series P220 or Watts Series 3L pressure type, Wilkins Series TP220 or Watts Series 40 temperature and pressure type, or approved alternate, relief valve with bronze body, bolted cap, non-metallic disc to metal seating, with elevated seat design, test lever and extended copper sheathed (thermostat) release mechanism.

3 Execution

3.1 Examination

.1 Verify that excavations are to required grade, dry, and not over-excavated.

3.2 Preparation

.1 Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

.2 Remove scale and dirt, on inside and outside, before assembly.

.3 Prepare piping connections to equipment with flanges or unions.

3.3 Installation

.1 Install to manufacturer's instructions.

.2 Provide non-conducting dielectric connections wherever jointing dissimilar metals.

.3 Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.

.4 Install piping to maintain headroom, conserve space, and not interfere with use of space.

.5 Group piping whenever practical at common elevations.

.6 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

.7 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

.8 Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with general trades.

.9 Establish elevations of buried piping outside the building to ensure not less than 4 ft. (1.2 m) of cover.

.10 Install vent piping penetrating roofed areas to maintain integrity of roof assembly; refer to Division 07.

.11 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

.12 Provide support for utility meters to requirements of utility companies.

.13 Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting where required. Coordinate with general trades.

.14 Excavate and backfill as required for work of this Section.

.15 Install bell and spigot pipe with bell end upstream.

.16 Install valves with stems upright or horizontal, not inverted.

.17 Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.

.18 Sleeve pipes passing through partitions, walls and floors.

.19 Inserts:

.1 Provide inserts for placement in concrete formwork.

.2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

.3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 in. (100 mm).

.4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

.5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

.20 Pipe Hangers and Supports:

.1 Install to OBC.

.2 Support horizontal piping as scheduled.

.3 Install hangers to provide minimum ½ in. (13 mm) space between finished covering and adjacent work.

.4 Place hangers within 12 in. (300 mm) of each horizontal elbow.

.5 Use hangers with 1½ in. (38 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.

.6 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.

.7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

.8 Provide copper plated hangers and supports for copper piping.

.9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

.10 Provide hangers adjacent to motor driven equipment with vibration isolation.

.11 Support cast iron drainage piping at every joint.

3.4 Application

.1 Install unions downstream of valves and at equipment or apparatus connections.

.2 Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.

.3 Install gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.

.4 Install globe valves for throttling, bypass, or manual flow control services.

.5 Provide spring loaded check valves on discharge of water pumps.

.6 Provide flow controls in water re-circulating systems where indicated.

3.5 Erection tolerances

.1 Establish invert elevations, slopes for drainage to 2 % minimum. Maintain gradients.

.2 Slope water piping minimum 0.25 % and arrange to drain at low points.

3.6 Disinfection of potable water piping

.1 Disinfect water distribution system.

.2 Prior to starting work, verify system is complete, flushed and clean.

.3 Ensure pH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).

.4 Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

.5 Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 % of outlets.

.6 Maintain disinfectant in system for twenty four (24) hours.

.7 If final disinfectant residual tests less than 25 mg/L, repeat treatment.

.8 Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.

.9 Take samples no sooner than twenty four (24) hours after flushing, from 10 % of outlets and from water entry, and analyze to AWWA C651.

3.7 Service connections

.1 Provide new sanitary sewer services. Before commencing work, check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.

.2 Provide new water service complete with approved reduced pressure backflow preventer and water meter with by-pass valves pressure reducing valve.

End of section

1 General

1.1 Section includes

.1 Roof drains

.2 Floor drains

.3 Trench drains

.4 Cleanouts

.5 Hose bibs

.6 Hydrants

.7 Hose racks

.8 Backflow preventers and Check valves

.9 Water hammer arrestors

.10 Potable hot water automatic flow limiting and balancing valves

.11 Partition stops

.12 Mixing valves

.13 Thermostatic mixing valves

.14 Trap Seal Primers

.15 Portable pressure washers

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 ASME A112.21.1 - Floor Drains.

.2 ASME A112.6.4 - Roof, Deck, and Balcony Drains.

.3 ASME A112.26.1 - Water Hammer Arrestors.

.4 ASSE 1011 - Hose Connection Vacuum Breakers.

.5 ASSE 1013 - Backflow Preventers, Reduced Pressure Principle.

.6 ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types.

.7 AWWA C506 - Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types.

.8 PDI WH-201 - Water Hammer Arrestors.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit shop drawings for each plumbing specialty.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

.2 Provide listing/approval stamp, label or other marking on plumbing specialties are made to the specified standard(s).

1.6 Delivery, storage and protection

.1 Accept specialties on site in original factory packaging. Inspect for damage.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Manufacturer: Watts Drainage model indicated or equivalent by:

.1 Zurn;

.2 Jay R. Smith;

.3 Precision Plumbing Products;

.4 Lawler;

.5 Febco; or

.6 Approved alternate.

2.3 Roof drains (RD)

.1 Built - Up Roofs

.1 Manufacturer: Watts Drainage Model RD-100-BED-5-W-1 or approved alternate.

.2 Epoxy coated cast iron roof drain with deep sump, adjustable extension, wide serrated flashing flange, flashing clamp device with integral gravel stop and self interlocking polyethylene dome strainer.

.3 Accessories: Coordinate with roofing type, refer to Division 07:

.1 Sediment bucket.

.2 Sump receiver.

.3 Under deck clamp.

.4 Water proofing flange.

.2 Landscaped Roofs

.1 Manufacturer: Watts Drainage Model RD-100-85-5-B-D-E-GSS-H-W-1-SO or approved alternate.

.2 Epoxy coated cast iron small sump roof drain with wide serrated flashing flange, flashing clamp device with integral gravel stop, stainless steel perforated 6 in. (150 mm) high ballast guard and self locking polyethylene dome strainer.

.3 Accessories: Coordinate with roofing type, refer to Division 07.

.1 Sediment bucket.

.2 Sump receiver.

.3 Under deck clamp.

.4 Adjustable extension.

.5 Water proofing flange.

.6 Side outlet

.3 Gutters

.1 Manufacturer: Watts Drainage Model RD-270-8 or approved alternate.

.2 Epoxy coated, cast iron body, flashing clamp, epoxy coated, cast iron grate secured angle grate, with backwater valve 90 ° no hub outlet.

.3 Accessories: Coordinate with roof type, refer to Division 07.

.1 Backwater valve.

2.4 Floor drains

.1 Floor Drain (FD):

.1 Manufacturer: Watts Drainage model FD-100-C-A5-1-5 or approved alternate.

.2 Epoxy coated cast iron floor drain with anchor flange, reversible membrane clamp with primary and secondary weep hole, ¼ in. (9 mm) thick 5 in. (125 mm) adjustable nickel bronze strainer grate, trap seal primer connection and no hub outlet.

.3 Accessories:

.1 Sediment bucket.

.2 Funnel Floor Drain (FFD):

.1 Manufacturer: Watts Drainage Model FD-100-C-EG-1-5 or approved alternate.

.2 Epoxy coated cast iron floor drain with anchor flange, reversible membrane clamp with primary and secondary weep holes, ¼ in. (6 mm) thick 5 in. (125 mm) adjustable nickel bronze strainer, 4 in. x 9 in. (100 x 225 mm) oval nickel bronze funnel, trap seal primer connection and no hub outlet

.3 Accessories:

.1 Sediment bucket.

.3 Area Drain (AD-1):

.1 Manufacturer: Watts Drainage Model FD-330-Y or approved alternate.

.2 Epoxy coated cast iron area drain with anchor flange, weepholes, 8 in. x 8 in. (203 x 203mm) square fixed top with heel proof ductile iron grate, and no hub (standard) outlet.

2.5 Trap seal primers (TSP)

.1 Individual Trap

.1 Manufacturer: Watts Drainage Model MS-810 or approved alternate.

.2 All brass trap seal primer with integral vacuum breaker, ½ in. (13 mm) copper sweat inlet and outlet connection and ½ in. (13 mm) IPS drip line connection.

.2 Flush Valve

.1 Manufacturer: Precision Plumbing Products FVP-1VB or approved alternate.

.2 Lead free cast brass body, activated during flush valve operation, 3 oz (0.09 L) of water will flow through priming tube to floor drain trap, flush valve primer should always be installed with vacuum breaker.

.3 Electronic Type

.1 Activated by a ¾ in. (19 mm) normally closed solenoid valve, designed to interface with low voltage energy management systems control, ¾ in. (19 mm) diameter connection anti-siphon atmospheric vacuum breaker.

.2 Electronic trap primer units shall be Precision Plumbing Products, models as follows:

.1 Model PT-4 for up to four (4) trap system;

.2 Model PT-6 for up to six (6) trap system;

.3 Model PT-8 for up to eight (8) trap system;

.4 Model PT-10 for up to ten (10) trap system;

.5 Model PT-12 for up to twelve (12) trap system; or

.6 Approved alternate.

.3 Each unit shall be a packaged electronic trap priming manifold, to supply a minimum of 2 oz. (59 mL) water per outlet port (based on 20-100 psi (137 kPa-689 kPa) system pressure), for six (6) seconds every twenty four (24) hours as minimum.

.4 The entire unit shall be factory assembled and comply pre-piped etc. for installation and shall include:

.1 Bronze body ¾ in. (19 mm) female NPT ball valve

.2 Electronic brass body ¾ in. (19 mm) solenoid valve (120 V)

.3 Atmospheric type vacuum breaker

.4 Type L copper outlet manifold

.5 ½ in. (13 mm) O.D. brass compression outlet fittings with orificed opening (for water balancing to each trap) connected from outlet manifold.

.5 Electrical components shall include:

.1 Single point 120 V/1ph/60 Hz power connection

.2 Manual override switch

.3 2 amp breaker

.4 Twenty four (24) hour field adjustable geared timer with adjustable dwell function (0-30 sec range)

.6 All components shall be factory mounted, assembled and tested, and supplied in a 16 gauge primed steel enclosure suitable for surface mounting (or recessed) mounting with hinged locking, door.

.7 All plumbing and electrical components shall be fully CSA approved.

.8 Unit shall be installed complete with 120 in. (3 m) length of 14/2 with ground power cable with male three (3) prong plug attached.

.9 Contractor shall `Cap Off' any unused water outlets.

2.6 Cleanouts (CO)

.1 Interior Unfinished Areas:

.1 Manufacturer: Watts Drainage Model CO-200-RX-4 or approved alternate.

.1 Epoxy coated cast iron floor cleanout with 5 in. (127 mm) round adjustable gasketed heavy duty ductile iron top, removable gas tight gasketed brass cleanout plug and no hub connection.

.2 Interior Finished Floor Areas:

.1 Manufacturer: Watts Drainage Model CO-200-R or approved alternate.

.1 Epoxy coated cast iron floor cleanout with 5 in. (127 mm) round adjustable gasketed nickel bronze top, removable gas tight gasketed brass cleanout plug and no hub connection.

.2 Manufacturer: Watts Drainage Model CO-200-TS-1 or approved alternate.

.1 Epoxy coated cast iron body, 5 in. x 5 in. (127 mm x 127 mm) square adjustable gasketed nickel bronze top with tile recess, removable gas tight gasketed brass cleanout plug, no hub outlet.

.3 Interior Finished Wall Stack Cleanout:

.1 Manufacturer: Watts Drainage Model CO-460-RD or approved alternate.

.2 Cast iron body with gasketed brass countersunk plug, stainless steel access cover, vandal proof stainless steel screw and no hub connections.

.4 Interior Stack Cleanout:

.1 Manufacturer: Watts Drainage Model CO-460 or approved alternate.

.2 Cast iron body with gasketed brass countersunk plug and no hub connections.

.5 Line Cleanout:

.1 Manufacturer: Watts Drainage Model CO-450-RD or approved alternate.

.2 Epoxy coated cast iron wall cleanout with gasketed cover, no hub connection, stainless steel access cover, and vandal proof stainless steel screw.

.6 Caulking for cleanouts:

.1 VOC content not to exceed 50 g/L.

2.7 Hydrants

.1 Exterior Wall Hydrant – Single Temperature (WH-1)

.1 Manufacturer: Watts Drainage Model HY-725 or approved alternate.

.2 Concealed non-freeze key operated wall hydrant with nickel bronze box and door, chrome plated hydrant face, integral vacuum breaker, ¾ in. (19 mm) hose connection, all bronze head, seat casting and internal working parts, galvanized wall casing and hydrant key.

.2 Interior Wall Hydrant – Dual Temperature (WH-2)

.1 Manufacturer: Watts Drainage Model HY-300-2-VB or approved alternate.

.2 Concealed key operated dual-temp wall hydrant with nickel bronze box and door, polished bronze hydrant face, ¾ in. (19 mm) hose connection, vacuum breaker, all bronze head, seat casting and internal working parts, galvanized wall casing, and hydrant key

.3 Poof Hydrant (PH-1)

.1 Manufacturer: Watts Drainage HY-600 or approved alternate.

.2 Non-freeze roof hydrant with Epoxy coated cast iron, galvanized casing, all bronze head and internal working parts

2.8 Hose bib (HB)

.1 Manufacturer: Watts Drainage Series HB-1 or approved alternate.

.2 Brass body construction with ½ in. (13 mm) copper x ¾ in. (19 mm) hose thread connection, hose coupling, integral vacuum breaker, built-in backflow protection, and cast iron hand wheel.

2.9 Backflow preventers (BFP), check valves

.1 Double Check Valve Assembly (DCVA)

.1 Manufacturer: Watts Drainage Series 007-QTM2 or approved alternate.

.2 The assembly shall consist of two positive seating check modules with captured springs and rubber seat discs. The check module seats and seat discs shall be replaceable. Service of all internal components shall be through a single bronze or stainless steel access cover secured with stainless steel bolts. The assembly shall also include two resilient seated isolation valves; four top mounted, resilient seated test cocks.

.3 Compliance with CSA B64 and shall meet the requirements of ASSE Std. 1015 and AWWA Std. C510.

.2 Reduced Pressure Backflow Preventers (RPBFP):

.1 Manufacturer: Watts Drainage Series LF909-QT-S or approved alternate.

.2 Lead Free cast copper silicon alloy body with two in-line, independent check valves, captured springs and replaceable check seats with an intermediate relief valve. Silicone rubber disc material in the first and second check plus the relief valve. Replaceable polymer check seats for first and second checks. Removable stainless steel relief valve seat and Stainless steel cover bolts. Assembled with two quarter-turn ball valves, strainer and four ball valve test cocks.

.3 Compliance with CSA B64 and ANSI/ASSE 1013.

.3 Single Check Valve serving equipment and appliances (coffee machines, water coolers, etc.)

.1 Manufacturer: Watts LF601 or approved alternate.

.2 Lead Free* cast copper silicon alloy Maxi-Flo Check Valves, or approved alternate, used to prevent the effects of water hammer in the piping system. Lead Free* copper silicon alloy body, Viton disc, and integral copper silicon alloy seat. Low pressure drop, can be installed in a horizontal or vertical position.

.4 Vacuum Breakers

.1 Manufacturer: Watts Drainage Model LF800M4QT or approved alternate.

.2 Acetal bonnet with silicon rubber O-ring seal, lead free cast copper silicon alloy body, stainless steel springs, replaceable seat, silicone rubber seat disc, v-notch guided check assembly, tee handle quarter turn ball valve shut-offs, test cocks positioned for easy testing and winterization.

2.10 Water hammer arrestors

.1 Manufacturer: Watts Drainage Series LF15M2 or approved alternate.

.2 Pre-charged, copper body, polypropylene piston, EPDM o-ring seal, permanent sealed air chamber to absorb shock, NPT solid hex lead free brass adapter for easy installation, maintenance free-piston is the only moving part, air pre-load is 60 psi (4.2 bar). Designed to operate on all domestic and commercial lines up to 150 psi (10.6bar) working pressure.

2.11 Trench drain (TD)

.1 Trench Drain

.1 Manufacturer: Watts Drainage Model Dead Level D-DI-ADA or approved alternate.

.2 6 in. (152 mm) wide x 48 in. (1,219 mm) long (standard) ductile iron frame, UV stabilized talc-filled polypropylene channels with integral 4 in. (102 mm) No Hub end outlet(s). System shall be frame-anchored, with ductile iron, ADA compliant grating to suit DIN Class E load rating. System to include frame connectors, grate lockdowns, and construction covers.

.2 Catch Basin

.1 Small

.1 Manufacturer: Watts Drainage Model CB-624-DI-ADA-T or approved alternate.

.2 UV stabilized talc-filled polypropylene channels with integral 4 in. (102 mm) and 6 in. (152 mm) no hub bottom outlets, 6 in. (152 mm) wide, 24 in. (610 mm) long, frame-anchored with specified grating and lockdowns to suit DIN class load rating, ductile iron frame, framed anchored grate, ductile iron ADA grate, Class F, trash basket.

.2 Large

.1 Manufacturer: Watts Drainage Model CB-2424-DI-ADA-T or approved alternate.

.2 UV stabilized talc-filled polypropylene channels with integral 4 in. (102 mm) and 6 in. (152 mm) no hub bottom outlets, 24 in. (610 mm) wide, 24 in. (610 mm) long, frame-anchored with specified grating and lockdowns to suit DIN class load rating, ductile iron frame, framed anchored grate, ductile iron ADA grate, Class F, trash basket.

.3 Installation to be performed in accordance with manufacturer's instructions and building code.

2.12 Potable hot water automatic flow limiting & balancing valves

.1 Brass, Solder end type, lead free, automatic flow limiting valve, valves designed to facilitate precise flow balancing of potable hot water. Operating pressure between 2 to 80 psi. Operating temperature range between 32 °F to 212 °F. Complete with changeable GPM flow cartridges, EPDM O-Ring and diaphragm, Polyphyenylsulfone orifice and certified to NSF/ANSI 61 & 372. Acceptable products are:

.1 Caleffi AutoFlow 127 Series;

.2 Hays Fluid Controls Model 2517LF; or

.3 Approved alternate.

.2 Solder end type, globe style, non-ferrous circuit balancing valves designed to facilitate precise flow measurement, precision flow balancing, and positive shut-off, complete with valved ports for connection to a differential pressure meter. Certified to NSF/ANSI 61 & 372. Acceptable products are:

.1 Armstrong Fluid Technology Model CBV-S;

.2 Tour and Anderson Model TBV-S or STAD/STAS;

.3 RWV #9519AB; or

.4 Approved alternate.

2.13 Mixing valves (MV)

.1 Laundry Boxes

.1 Single Temperature

.1 Manufacturer: Precision Plumbing Products MM-500 MIMB or approved alternate.

.2 Constructed of 20 ga. (1.0 mm) steel box, white powder coat finish, includes necessary mounting brackets and faceplate, 2 in. Ø (51 mm) rubber drain pipe coupling for connection, barrel-fabricated of type L hard drawn copper, cap machined of free turning brass, composite materials for piston, EPDM seal, Dow-Corning silicone compound #111, FDA listed for use in potable water systems, designed to operate on all domestic and commercial systems. Normal operating pressure 0 to 80psig, max spike pressure 250psig, -40 °F to 212 °F (-4.4 °C to 100 °C), quarter turn ball valve.

.2 Dual Temperature

.1 Manufacturer: Precision Plumbing Products MM-500 MLB or approved alternate.

.2 Constructed of 20 ga. (1.0 mm) steel box, white powder coat finish, includes necessary mounting brackets and faceplate, 2 in. Ø (51mm) rubber drain pipe coupling for connection, water hammer arrestor-fabricated of type L hard drawn copper, cap machined of free turning brass, composite materials for piston, EPDM seal, Dow-Corning silicone compound #111 (or approved alternate), FDA listed for use in potable water systems, designed to operate on all domestic and commercial systems. Normal operating pressure 0 to 80 psig, max spike pressure 250 psig, -40 °F to 212 °F (-4.4 °C to 100 °C), quarter turn ball valve.

.3 Manufacturer: Leonard Valve SW-75-EVBD-RF or approved alternate.

.1 Manual water blender with 19 mm (¾ in.) IPS hot water inlet and cold water inlet, two stop and check valves with colour coded heat resistant handles on inlets, (internal parts of stainless steel construction), stainless steel mixing chamber with 19 mm (¾ in.) outlet with dial thermometer -5 to 115 ºC (20 to 240 ºF), vacuum breaker, chrome plated finish, hose connection, hose rack and a maximum operating pressure of 125 PSI (8.6 bar).

2.14 Thermostatic mixing valves

.1 Point of Use – Non-Emergency Device

.1 Manufacturer: Lawler Safety TMM-1070 or approved alternate.

.2 Bronze body construction, high temperature limit stop with shut off temperature of 118 °F (+/- 3 °F), integral rubber duck-bill back-flow checks within inlets, temperature adjustment dial, thermostatic mechanical mixing valve with outlet temperature range within 95-115 °F (35 - 46 °C), ASSE 1070 approved, valve shall control temperature from a low of ½ gpm, 1 gpm at 10 psi and 1.6 gpm at 20 psi drop across the valve, 3/8 in. Ø compression fit inlets and outlets, ASSE Lead Free Certified.

3 Execution

3.1 General

.1 Install all products in accordance with the plumbing code and with manufacturer's instructions.

3.2 Roof drains

.1 Locate roof drains where indicated on roofing plans.

.2 Inspect locations where roof drains are shown to determine that roof is sloped appropriately. Report concerns to Consultant prior to installation of drains.

.3 Coordinate installation with roofing trade.

3.3 Floor drains

.1 Provide floor drains where indicated on architectural and plumbing floor plans.

.2 Inspect locations where floor drains are shown to determine that floor is sloped appropriately. Report concerns to Consultant prior to installation of drains.

.3 Coordinate installation with general trades.

.4 Trap and vent all floor drains in accordance with Plumbing Code.

.5 Provide trap seal priming for each floor drain trap.

.6 Floor drains in floors with surface membranes shall be installed with a membrane clamp and anchoring flange.

.7 Floor drains, traps and drain pipes installed in slabs on grade shall be embedded in concrete and made water-tight to prevent water seepage.

3.4 Trap seal primers

.1 Traps may be primed from the flush tube of a flush valve or from the waste of a drinking fountain.

.2 No more than three (3) traps may be primed from one flush valve or one drinking fountain.

.3 Condensate drains from cooling units may not be used to prime traps.

.4 Trap seal primers shall be provided where flush valves and/or drinking fountains are not available.

.5 Group trap primers shall be provided where specifically shown and where agreed with the Consultant.

3.5 Cleanouts

.1 Cleanouts shall be the same size as the pipe up to 4 in. (100 mm) and not less than 4 in. (100 mm) for larger pipes.

.2 Provide cleanouts at the end of mains and branches, at changes in direction, in long straight runs and at the base of all soil stacks and rainwater leaders and where required by code.

.3 Extend cleanouts to finished floor or wall surface.

.4 Encase exterior cleanouts in concrete flush with grade.

.5 Install floor cleanouts at elevation to accommodate finished floor.

.6 Cleanouts in floors with surface membranes shall be installed with a membrane clamp and anchoring flange.

.7 Lubricate threaded cleanout plugs with mixture of graphite and linseed oil.

.8 Ensure clearance at cleanout for rodding of drainage system.

3.6 Hydrants

.1 Locate wall hydrants where indicated.

.2 Coordinate installation with general trades.

.3 Provide a shut-off valve at every hydrant and hose bibb.

3.7 Backflow preventers

.1 Backflow prevention includes backflow preventers, anti-siphon devices and vacuum breakers.

.2 Install approved potable water protection devices on plumbing lines where contamination of domestic water may occur;

.1 on hydronic feed water lines,

.2 housekeeping faucets,

.3 premise isolation,

.4 interior and exterior wall hydrants (hose bibbs).

.5 where require by codes, regulations and/or standards.

.3 Pipe relief or drain from backflow prevention device to nearest drain.

.4 Install a strainer upstream of each backflow preventer.

3.8 Water hammer arrestors

.1 Install water hammer arrestors complete with an accessible isolation valve on hot and cold water supply piping to;

.1 plumbing fixtures and fixture groups,

.2 Owner's equipment and appliances with flush valves, solenoid valves or other quick closing valves,

.3 downstream of each backflow preventer,

.4 wherever necessary to prevent water hammer.

3.9 Automatic flow limiting & balancing valves

.1 Provide balancing valve(s) in potable hot water recirculation piping where shown.

.2 Locate each valve such that it is easily accessible.

End of section

1 General

1.1 Section includes

.1 Wet rotor circulators.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 ASHRAE 90A - Energy Conservation in New Building Design.

.2 National Sanitation Foundation (NSF) No. 61: Drinking Water System components.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit shop drawings and product data for each pump in accordance with 20 01 00 – Mechanical General Requirements.

.4 Shop drawings shall include the following:

.1 Pump type, capacity, power requirements.

.2 Controls.

.3 Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.

.4 Provide electrical characteristics and connection requirements.

.5 Submit Operation and Maintenance manuals in accordance with Section 20 01 00 – Mechanical General Requirements.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum five (5) years documented experience.

.2 Provide pumps with manufacturer's name, model number, and rating/capacity identified.

.3 Ensure products and installation of specified products are to recommendations and requirements of the following organizations:

.1 National Sanitation Foundation (NSF).

.2 American Society of Mechanical Engineers (ASME).

.3 Canadian Standards Association (CSA)

.4 National Electrical Manufacturers' Association (NEMA).

.5 Underwriters Laboratories of Canada (ULC).

.4 Ensure pumps operate at specified system fluid temperatures without vapour binding and cavitations, are non-overloading in parallel or individual operation, operate within 25 % of midpoint of published maximum efficiency curve.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: CSA Listed and classified as suitable for the purpose specified and indicated.

1.7 Delivery, storage and protection

.1 Provide temporary inlet and outlet caps. Maintain caps in place until installation.

.2 Store and safe guard equipment, material and spare parts in accordance with the manufacturer’s guidelines.

1.8 Warranty

.1 Provide five (5) year manufacturer warranty starting from date of Substantial Performance for pumps.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Refer to schedules and schematics on the drawings.

.2 All domestic water pumps shall be of a single manufacturer.

.3 Acceptable manufacturer's subject to shop drawing review:

.1 Bell & Gossett / Xylem;

.2 S. A. Armstrong;

.3 Grundfos;

.4 Wilo;

.5 Taco; or

.6 Approved alternate.

2.3 Wet rotor circulators

.1 The pumps shall be of a high efficiency type specifically designed for quiet operation.

.2 Pumps shall have sensorless control to automatically adjust pump performance as required.

.3 Pumps shall be suitable for 110 °C (203 °F) operation at 10 Bar (150 psi) working pressure.

.4 The pumps shall have a shaft-less, wet rotor design with a ceramic ball bearing lubricated by system fluid.

.5 Motors shall be spherical electronically commutated motor (ECM), permanent magnet.

.6 Motors shall be non-overloading at any point on the entire curve.

.7 Motors shall be protected from contaminants to prevent clogging.

.8 Pumps shall be capable of speed modulation across the full speed range.

3 Execution

3.1 Installation

.1 In-line pump shall be supported from piping in true vertical alignment. For each pump, provide a shut off valve and strainer on the suction inlet side, and a check valve, balancing valve and shut off valve on the discharge side and pressure gauge.

.2 Confirm pump rotation is correct.

End of section

1 General

1.1 Section includes

.1 Tank type water heaters

.2 Expansion tanks

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

.2 Read and conform to:

.1 The Contract CCDC 2, Stipulated Price Contract as amended in the Contract Documents;

.2 Division 01 requirements and documents referred to therein.

1.3 References

.1 ASHRAE 90A - Energy Conservation in New Building Design.

.2 ASME Section 8D - Boilers and Pressure Vessel Codes - Rules for Construction of Pressure Vessels.

.3 ASSE 1017 – Standard for Master Thermostatic Mixing Valves.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit shop drawings and product data for each major piece of equipment.

.4 Shop drawings shall include:

.1 Dimension drawings of water heaters indicating components and connections to other equipment and piping.

.2 Electrical characteristics and connection requirements.

.3 Performance data.

.5 Submit project closeout as indicated in Division 01 including the following:

.1 Record actual locations of equipment.

.2 Operation, maintenance and inspection data, replacement part numbers and availability, and service locations and contact information.

.3 Manufacturer warranty and ensure all forms have been completed in the Client’s name and registered with the manufacturer.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

.2 Provide equipment with the manufacturer's name, model number, and rating/capacity identified.

.3 Ensure products and installation of specified products are to recommendations and requirements of the following organizations:

.1 National Sanitation Foundation (NSF).

.2 American Society of Mechanical Engineers (ASME).

.3 National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).

.4 National Electrical Manufacturers' Association (NEMA).

.5 Underwriters Laboratories (UL).

1.6 Regulatory requirements

.1 Conform to ASME Section 8D for manufacture of pressure vessels for heat exchangers.

.2 Conform to ASME Section 8D for tanks.

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

1.7 Delivery, storage and protection

.1 Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.8 Warranty

.1 Provide five (5) year manufacturer warranty, starting from date of Substantial Performance, for domestic water heaters and packaged water heating systems.

.2 Heater tank shall have a three (3) year limited warranty, starting from date of Substantial Performance, as outlined in the written warranty.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Tank type water heaters

.1 General

.1 Refer to schedule(s) on drawing(s) in conjunction with these specifications.

.2 Electric

.1 The water heater shall be Rheem Commercial Heavy Duty Electric Model as scheduled with minimum 98% efficiency or approved alternate. Heater shall be listed by Underwriters' Laboratories with ASME construction. Control box shall be located at the front of unit for easy wiring.

.2 Heater shall have a leak detection with audible alarm with built-in water management system, 1,034 kPa (150 psi) working pressure and be equipped with extruded high density anode rod.

.3 Electric heating elements shall be stainless steel with Sentinal diagnostic panel with LEDs, or approved alternate. Each element shall be controlled by an individually mounted thermostat and high temperature cut-off switch.

.4 Thermostats shall be immersion type

.5 The drain valve shall be located in the front for ease of servicing.

.6 Hot water tank temperature shall be monitored on the BAS.

.7 Acceptable alternates subject to shop drawing review:

.1 A. O. Smith Dura-Power Model;

.2 John Wood; or

.3 Other approved alternate.

2.3 Expansion tank

.1 ASME pre-charged for potable water diaphragm expansion tank, manufactured by S.A. Armstrong AST Series or approved alternate, stamped 150 psi (1034 kPa) working pressure. Each tank will be supplied with a heavy duty FDA approved butyl diaphragm. Tank sizes AST-20 to AST-210 shall be supplied with a ring base, lifting rings, and NPT system connection. An air charging valve connection (standard tire valve) shall be provided to facilitate adjusting pre-charge pressure to meet actual system conditions.

.2 Refer to schedule on drawing(s).

.3 Acceptable alternates subject to shop drawing review:

.1 Bell & Gossett; or

.2 Other approved alternate.

3 Execution

3.1 Installation

.1 Set domestic water heater in place where shown and install in strict accordance with manufacturer's written instructions and CGA requirements.

.2 Provide point-of-use water heater complete with a welded structural steel angle wall bracket for heater mounting and catch pan. Grind welds, clean and prime paint the assembly. Finish with two (2) coats of alkyd enamel paint.

.3 Extend pressure relief valve outlet piping at full line size, complete to drain. Drains and overflows shall be piped to the closet drain outlet. Install flue as required.

.4 All interconnecting piping and valves shall be provided as indicated in schematic arrangement as detailed on drawings.

.5 Check and test water heater operation and unless otherwise indicated, set the hot water discharge temperature to 60 °C (140 °F).

End of section

1 General

1.1 Section Includes

.1 Water closets,

.2 Lavatories,

.3 Sinks,

.4 Showers, and

.5 Emergency Fixtures.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

.3 Section 22 11 16 – Plumbing and Drainage Piping

1.3 References

.1 Canadian Standards Association (CSA International):

.1 CAN/CSA-B45 Series, Plumbing Fixtures.

.2 CAN/CSA-B125.3, Plumbing Fittings.

.3 CAN/CSA-B651, Accessible Design for the Built Environment.

1.4 Actions and informational submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data:

.1 Provide manufacturer’s printed product literature and datasheets for fixtures and include product characteristics, performance criteria, physical size, finish and limitations.

.4 Closeout Submittals:

.1 Provide maintenance data in accordance with Section 01 78 00 – Closeout Submittals.

.5 Include:

.1 Description of fixture and trim, giving manufacturer's name, type, model, year, capacity.

.2 Details of operation, servicing, maintenance.

.3 List of recommended spare parts.

.6 Include diagrams for power, signal, and control wiring of automatic faucets.

1.5 Delivery storage and disposal

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling.

.2 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material, in appropriate on-site bins.

.3 Fold up metal and plastic banding, flatten and place in designated area for recycling.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Plumbing fixture and fitting schedule

.1 For plumbing fixture and fitting manufacturers, catalogue numbers, and specific requirements, refer to the Drawing schedule of plumbing fixtures and fittings.

.2 Unless otherwise specified in the Contract Documents, requirements specified below apply to the plumbing fixtures and fittings scheduled on the Drawings.

2.3 General: plumbing fixtures and fittings

.1 Fixtures and fittings, where applicable, shall be in accordance with the requirements of CSA B45 Series, Plumbing Fixtures.

.2 All fixtures and fittings for use by the handicapped are to be in accordance with Ontario Building Code requirements.

.3 Unless otherwise specified in the Contract Documents, all vitreous china and porcelain enamelled fixtures shall be white.

.4 Unless otherwise specified in the Contract Documents, all fittings exposed to view shall be chrome plated and polished.

.5 All fittings located in areas other than private washrooms shall be vandal-proof.

.6 All fixtures carriers shall be suitable in all respects for the fixture they support and the construction in which they are located.

2.4 Water closets

.1 Designation (W-1)

.1 Barrier Free, Wall Hung, Flush Valve Water Closet

.2 Fixture: American Standard Afwall Millennium FloWise Elongated no. 3351511 Toilet, or approved alternate, vitreous china with EverClean antimicrobial surface which inhibits the growth of stain and odor causing bacteria mold and mildew, elongated bowl, white finish, wall hung, siphon jet flush action, operates in the range of 4.2L to 6.0L (1.1 USG to 1.6U SG) per flush, condensate channel, 305 mm x 254 mm (12 in. x 10 in.) water surface, elongated bowl, 54 mm (2⅛ in.) fully glazed internal trapway, 38 mm (1½ in.) diameter top spud.

.3 Seat: Centoco no. 820STSS.001 Toilet Seat or approved alternate, extra heavy duty, for elongated bowl, open front, solid plastic, with cover, stainless steel self-sustaining check hinges, metal flat washers stainless steel posts and nuts.

.4 Valve: American Standard Selectronic 6065.111 or approved alternate, exposed flushometer for top spud toilet, polished chrome finish, 4.2 L (1.1 USG) factory set flow, water-sense labelled, Selectronic Proximity System universal sensor with prevented

ghost flushing, fail-safe upon loss of power or water pressure, mechanical manual override button to flush the valve without power, factory installed CR-P2 Lithium Battery with 4 years life and 4000 flushes per month, self-cleaning piston with integral wiper spring to reduce clogging and maintenance, prevented ghost flushing feature, adjustable sanitary flush, chemical resistant EPDM Seals for extended life, adjustable tailpiece for rough-in flexibility, left or right hand installation, angle stop with back-flow protection and vandal resistant cap. Provide extension for the flush valve to clear the lid and offset tube to allow for grab bar installation

.5 Carrier: Watts no. ISCA-101-M11 single horizontal adjustable toilet carrier or approved alternate, mounted on concrete floor, all epoxy coated cast iron fitting, adjustable ABS slide nipple with integral test cap and neoprene bowl gasket, wasted plated hardware, chrome cap nuts, tiling frame, 102 mm (4 in.) no hub waste, 51 mm (2 in.) no hub vent, 158.8 kg (350 lbs) static load. 305 mm (12 in.) finished metal stud wall to back of pipe space.

.2 Designation (W-2)

.1 General Use, Wall Hung, Flush Valve Water Closet.

.2 Fixture: American Standard Afwall Millennium FloWise Elongated no. 3351511 Toilet or approved alternate, vitreous china with EverClean antimicrobial surface which inhibits the growth of stain and odor causing bacteria mold and mildew, elongated bowl, white finish, wall hung, siphon jet flush action, operates in the range of 4.2 L to 6.0 L (1.1 USG to 1.6 USG) per flush, condensate channel, 305 mm x 254 mm (12 in. x 10 in.) water surface, elongated bowl, 54 mm (2⅛ in.) fully glazed internal trapway, 38 mm (1½ in.) diameter top spud.

.3 Seat: Centoco no. 500STSCCSS.001 toilet seat or approved alternate, heavy duty, for elongated bowl, open front, solid plastic, less cover, stainless steel self-sustaining check hinges, metal flat washers stainless steel posts and nuts.

.4 Valve: American Standard Selectronic 6065.111 or approved alternate, exposed flushometer for top spud toilet, polished chrome finish, 4.2 L (1.1 USG) factory set flow, water-sense labelled,

Selectronic Proximity System universal sensor with prevented ghost flushing, fail-safe upon loss of power or water pressure, mechanical manual override button to flush the valve without power, factory installed CR-P2 Lithium Battery with 4 years life and 4000 flushes per month, self-cleaning piston with integral wiper spring to reduce clogging and maintenance, prevented ghost flushing feature, adjustable sanitary flush, chemical resistant EPDM Seals for extended life, adjustable tailpiece for rough-in flexibility, left or right hand installation, angle stop with back-flow protection and vandal resistant cap.

.5 Carrier: Watts no. ISCA-101-M11 single horizontal adjustable toilet carrier or approved alternate, mounted on concrete floor, all epoxy coated cast iron fitting, adjustable ABS slide nipple with integral test cap and neoprene bowl gasket, wasted plated hardware, chrome cap nuts, tiling frame, 102 mm (4 in.) no hub waste, 51 mm (2 in.) no hub vent, 158.8 kg (350 lbs) static load. 305 mm (12 in.) finished metal stud wall to back of pipe space.

2.5 Lavatories

.1 Designation (L-1)

.1 Barrier Free Counter Mounted lavatory

.2 Fixture: American Standard Ovalyn Universal Access no. 9482.000.020 basin or approved alternate, no faucet hole drilling, 489 mm x 400 mm x 140 mm (19¼ in. x 15¾ in. x 5½ in.) high, oval, vitreous china, white finish, undercounter, rear overflow, no. 047194-007A undermount clips. Provide basin rim sealant.

.3 Faucet: American Standard Selectronic no. 6053104.002 faucet or approved alternate, water-sense labelled, center hole only, vandal resistant brass construction, 0.35 GPM (1.3 LPM) pressure compensating vandal-resistant multi-laminar spray, cast spout, 140 mm (5½ in.) projection reach, self-adjusting sensor, PWRX ten (10) year battery system.

.4 Thermostatic Mixing Valve: Lawler no. TMM-1070 or approved alternate, below deck mechanical water mixing valve, bronze body, temperature adjusting dial, 10mm (3/8 in.) inlets and outlet compression fittings, high temperature thermostatic limit stop, shut-

off with automatic reset when temperature exceeds 120 ºF (48.8 ºC), integral checks, offer temperature range from full cold through 46 °C (114.8 °F), housed in 356 mm x 356 mm x 152 mm (14 in. x 14 in. x 6 in.) recessed box. Provide tee, adaptors and flexible copper tubing to suit installation.

.5 Waste Fitting: McGuire no. 155WC open grid drain or approved alternate, cast brass one piece top, 17 ga. (1.5 mm) tubular 32 mm (1¼ in.) tailpiece.

.6 Supplies: McGuire no. LFH170BV faucet supplies or approved alternate, chrome plated finish polished brass, commercial duty ¼ turn ball valve angle stops, 13 mm (½ in.) I.D., inlet x 127 mm (5 in.) horizontal extension tubes, convertible ¼ turn/loose key handles, escutcheon and flexible copper risers.

.7 Trap: McGuire no. 8872C P-Trap or approved alternate, heavy cast brass adjustable body, with slip nut, 32 mm (1¼ in.) size, shallow wall flange and seamless tubular wall bend.

.2 Designation (L-2)

.1 Barrier free Wall Hung Lavatory

.2 Fixture: American Standard Murro no. 0955.001EC/0059.020EC basin or approved alternate, center hole only, 540 mm x 520 mm x 165 mm (21¼ in. x 20½ in. x 6½ in.) high, vitreous china, white finish, for carrier with concealed arms, rear overflow, recessed self-draining faucet ledge, semi-pedestal P-trap cover.

.3 Faucet: American Standard Selectronic no. 6053.104.002 faucet or approved alternate, water-sense labelled, center hole only, vandal resistant brass construction, 0.35 GPM (1.3 LPM) pressure compensating vandal-resistant multi-laminar spray, cast spout, 140 mm (5½ in.) projection reach, self-adjusting sensor, PWRX ten (10) year battery system.

.4 Thermostatic Mixing Valve: Lawler no. TMM-1070 or approved alternate, below deck mechanical water mixing valve, bronze body, temperature adjusting dial, 10 mm (⅜ in.) inlets and outlet compression fittings, high temperature thermostatic limit stop, shut-off with automatic reset when temperature exceeds 120 ºF (48.8 ºC), integral checks, offer temperature range from full cold through

46 °C (114.8 °F). Provide tee, adaptors and flexible copper tubing to suit installation.

.5 Waste Fitting: McGuire no. 155 A open grid drain or approved alternate, cast brass one piece top, 17 ga. (1.5 mm) tubular 32 mm (1¼ in.) tailpiece.

.6 Supplies: McGuire no. LFH170BVRB faucet supplies or approved alternate, chrome plated finish polished brass, commercial duty ¼ turn ball valve angle stops, 13 mm (½ in.) I.D., inlet x 127 mm (5 in.) horizontal extension tubes, convertible ¼ turn/loose key handles, escutcheon and stainless steel braided flexible risers.

.7 Trap: McGuire no. 8872C P-Trap or approved alternate, heavy cast brass adjustable body, with slip nut, 32 mm (1¼ in.) size, shallow wall flange and seamless tubular wall bend.

.8 Carrier: Watts no. WCA-411 basin carrier or approved alternate, concealed arms, wall flanges to attach to backing plate secured in wall with locking device and levelling screws, heavy gauge steel uprights with integral welded feet. For one unit: 102 mm (4 in.) for two (2) to six (6) units in a row: 152 mm (6 in.) finished metal stud wall to back of pipe space.

2.6 Sinks

.1 Designation (S-1)

.1 Single Compartment Stainless Steel Sink

.2 Fixture: Franke Commercial no. ALBS4006P-1/1 single bowl countertop mount sink or approved alternate, 1 hole, 562mm (22-1/8") wide x 478mm (18-13/16") long x 152mm (6") deep, counter mounted, back ledge, grade 18-10 18ga. (1.2mm) type 304 stainless steel, self-rimming, satin finish rim and bowls, mounting kit provided, fully undercoated to reduce condensation and resonance, factory applied rim seal, 3-1/2" (89mm) crumb cup waste assembly with 1-1/2" (38mm) tailpiece.

.3 Faucet: Chicago Faucets 116.430.AB.1 HyTronic Electronic 'No Touch' Battery powered Faucet or approved alternate, chrome plated finish, Center hole only, ECAST construction lead free (equal or less than 0.25%) Cast brass body, 5.7 LPM (1.5 GPM) laminar

flow control insert in spout inlet, plain end outlet, 133 mm (5-1/4") projection flow control rigid/swing gooseneck spout,dual beam infrared sensor on faucet base, mixing valve by others, 6 volt lithium CR-P2 commercial battery included, stainless steel hose.

.4 Thermostatic Mixing Valve: Lawler no. TMM-1070 or approved alternate, below deck mechanical water mixing valve, bronze body, temperature adjusting dial, 10mm (3/8") inlets and outlet compression fittings, high temperature thermostatic limit stop, shut-off with automatic reset when temperature exceeds 120ºF (48.8ºC), integral checks, offer temperature range from full cold through 46°C (114.8°F). Provide tee, adaptors and flexible copper tubing to suit installation.

.5 Supplies: McGuire no. LFH165LKN3 faucet supplies or approved alternate, chrome plated finish polished brass, heavy duty angle stops, 10 mm (3/8") I.P.S. Inlet x 76 mm (3") long rigid horizontal nipples, V.P. Loose keys, Escutcheon and flexible copper risers.

.6 Trap: McGuire no. 8912CB P-Trap or approved alternate, heavy cast brass adjustable body, with slip nut, 38mm (1-1/2") size, box flange and seamless tubular wall bend.

.2 Designation (S-2)

.1 Two Compartment Stainless Steel Sink

.2 Fixture: Franke Commercial no. ALBD6406P-1/1 double bowl countertop mount sink or approved alternate, 1 hole, 794mm (31-1/4") wide x 521mm (20-1/2") long x 152mm (6") deep, spillway, counter mounted, back ledge, grade 18-10 18ga. (1.2mm) type 304 stainless steel, self-rimming, satin finish rim and bowls, mounting kit provided, fully undercoated to reduce condensation and resonance, factory applied rim seal, 3-1/2" (89mm) crumb cup waste assembly with 1-1/2" (38mm) tailpiece.

.3 Faucet: Chicago Faucets 116.430.AB.1 HyTronic Electronic 'No Touch' Battery powered Faucet or approved alternate, chrome plated finish, Center hole only, ECAST construction lead free (equal or less than 0.25%) Cast brass body, 5.7 LPM (1.5 GPM) laminar flow control insert in spout inlet, plain end outlet, 133 mm (5-1/4") projection flow control rigid/swing gooseneck spout,dual beam

infrared sensor on faucet base, mixing valve by others, 6 volt lithium CR-P2 commercial battery included, stainless steel hose.

.4 Thermostatic Mixing Valve: Lawler no. TMM-1070 or approved alternate, below deck mechanical water mixing valve, bronze body, temperature adjusting dial, 10mm (3/8") inlets and outlet compression fittings, high temperature thermostatic limit stop, shut-off with automatic reset when temperature exceeds 120ºF (48.8ºC), integral checks, offer temperature range from full cold through 46°C (114.8°F). Provide tee, adaptors and flexible copper tubing to suit installation.

.5 Supplies: McGuire no. LFH165LKN3 faucet supplies or approved alternate, chrome plated finish polished brass, heavy duty angle stops, 10 mm (3/8") I.P.S. Inlet x 76 mm (3") long rigid horizontal nipples, V.P. Loose keys, Escutcheon and flexible copper risers.

.6 Trap: McGuire no. 8912CB P-Trap or approved alternate, heavy cast brass adjustable body, with slip nut, 38mm (1-1/2") size, box flange and seamless tubular wall bend.

.3 Designation (S-3)

.1 Floor Mounted Service Sink

.2 Fixture: Stern-Williams no. MTB2424100 square service / mop sink or approved alternate, 610 mm (24 in.) wide x 610 mm (24 in.) long x 254 mm (10 in.) deep, floor mounted, terrazzo composed of pearl gray marble chips and Portland cement ground sealed to resist stain finish-cast brass drain with stainless steel strainer, 3 in. (76 mm) outlet.

.3 Faucet: American Standard no. 8354112.002 wall mounted two handles scullery faucet or approved alternate, polished chrome finish, flexible installation within the range of 6 in. (152 mm) to 10 in. (254 mm), cast brass body, integral stops, washerless ceramic disc valve cartridges, 22.7 LPM (6.0 GPM) unrestricted hose end outlet, atmospheric vacuum breaker and bucket hook, 237 mm (9 5/16 in.) from wall to outlet reach, cross handle, top brace.

.4 Bumper Guard: Stern Williams no. A-20bumper guard anodized aluminum cap or approved alternate.

.5 Hose & Wall Hook: Stern Williams no. T-35 hose and wall hook or approved alternate, 36 in. (914 mm) long flexible hose, with ¾ in. chrome coupling. Stainless steel wall bracket.

.6 Mop Hanger: Stern Williams no. T-40 mop hanger or approved alternate, 22 ga. (0.8 mm) type 304 stainless steel.

.7 BP Back Splash Panel 20 GA. (0.9 mm) type 304 stainless steel.

.8 TC-3 Gasket 3 in. (76 mm) for XHCI, plastic and steel pipe.

2.7 Bottle/Glass Filling Station

.1 Designation (WBF-1)

.1 Fixture: Elkay EZH2O Bottle Filling Station, (or approved alternate) Filtered In-Wall Recessed (non-chilled) #LZWSMDK In-Wall Recessed Mounted bottle/glass filling station (Filler (LZWSMDC), Mounting Frame (MFWS100), and Filter (EWF3000) are included), sensor, touchless activation with auto 20-second shut off (bottle filler), single, 8 GPH of 50 ºF drinking water at 90 ºF ambient and 80 ºF inlet water, non-chilled water delivered, laminar flow provides minimal back splash, lead-free design, real drain system eliminates standing water, stainless steel bottle filler wrapper with ABS plastic alcove, quick fill rate of 1.5 gpm, Innovative Green Ticker counts bottles saved from waste. Current of 1.0 Amps, power consumption: 15W, WaterSentry Plus 3000-gallon capacity filtration system, NSF/ANSI 42 & 53 certified, LED Visual Filter Monitor shows replacement when necessary, Green Spec Listed. Integrated silver ion anti-microbial protection in key areas. Provide electrical duplex box with GFI.

.2 Supplies: McGuire no. LFHSTLK drinking fountain supplies (or approved alternate), chrome plated finish polished brass, straight stops, vandal proof loose keys, low lead.

2.8 Showers

.1 Designation: SH-1 (Barrier Free)

.1 Valve: American Standard ‘Ceramix’ No. T000.500XH/R120SS shower valve, or approved alternate, pressure balancing mixing valve, brass body, washer-less ceramic drip-free disc valve

cartridge, integral hot limit stop, screwdriver stops with separate checks. Brass wall escutcheon, metal lever handle.

.2 Head: American Standard No. 1660.710 or approved alternate, water saving showerhead, water-sense labelled, turbine spray, adjustable angle, 5.7 LPM (1.5 GPM) maximum flow rate.

.3 Diverter and Trim: American Standard No. T005.430 or approved alternate, metal lever handles. American Standard No. R420, 2-Way in-wall diverter valve.

.4 Wand: American Standard No. 1662.604 water-saving soft spray hand shower or approved alternate, 5.7 LPM (1.5 GPM) maximum flow rate, spray pattern adjust from conventional spray to gentle flow to massage, easy clean rubber nozzles.

.5 Vacuum Breaker: American Standard No. 1660.400 hand shower vacuum breaker or approved alternate, between supply outlet and personal shower hose.

2.9 Emergency fixtures

.1 Designation: (E-1)

.1 Fixture: Guardian no. G1750P-T-YEL or approved alternate, wall mounted, eye/face wash, 298 mm (11¾ in.) diameter bowl, yellow ABS plastic bowl, two (2) FS-Plus spray heads with flip-top dust cover and filter, powder coated cast aluminum flag handle activation, ½ in. (13 mm) IPS chrome plated brass stay-open ball valve with Teflon seal, heavy duty cast aluminum wall bracket with corrosion resistant powder coated finish, chrome plated brass tailpiece and trap with 1½ in. (38 mm) IPS waste connection, 1¼ in. (32 mm) NPT female outlet. Unit is third party certified by IAPMO to meet ANSI Z358.1, the Uniform Plumbing Code cUPC and the National Plumbing Code of Canada. Eyewash/Facewash fixture should be installed 4 to 10 ft. from the mixing valve.

.2 Thermostatic Mixing Valve: Lawler no. 911E/F or approved alternate, emergency thermostatic mixing valve for Eyewash or Eye/Face Wash, lead-free brass and stainless steel design, vandal resistant temperature adjustment, stainless steel sliding piston control device allow cold flow through both the fixed and variable

bypass, 13 mm (½ in.) N.P.T., outlet, positive hot water shut-off, liquid-filled thermostatic motor control mechanism, 29 °C (84.2 °F) factory set temperature, standard 69.8 °F (21 °C) - 89.6 °F (32 °C) temperature range, 26 LPM (6.9 GPM) flow capacity at 30 psi (207 kPa) pressure drop across the valve, 7.57 LPM (2.0 GPM) min. Flow rate, 18 LPM (4.8 GPM) bypass flowrate at 30 psig. Provide shut-offs at emergency mixing valve.

2.10 Acceptable manufacturers

.1 Vitreous china and enameled cast iron or steel fixtures: Zurn, Sloan, American Standard, Toto, Kohler, or other approved alternate.

.2 Stainless steel sinks: Franke, AERO, Novanni Stainless Inc., Kindred Industries "Aristaline" , or other approved alternate.

.3 Precast terrazzo fixtures: Acorn, Fiat Products Ltd. and Stern-Williams, or other approved alternate.

.4 Water closet seats: Zurn, Bemis, Centoco, Olsonite and Beneke, or other approved alternate.

.5 Flush valves: Zurn, Sloan, American Standard, Toto, and Delta Commercial, or other approved alternate.

.6 Fixture carriers: Zurn, Mifab, Jay R. Smith and Watts Industries, or other approved alternate.

.7 Faucets: unless otherwise specified, Zurn, Delta Commercial, American Standard, Kohler and Chicago Faucet, or other approved alternate.

.8 Fixture trim: unless otherwise specified, McGuire, Zurn, American Standard , Kohler, or other approved alternate.

3 Execution

3.1 Installation of plumbing fixtures and fittings

.1 Provide all required plumbing fixtures and fittings.

.2 Provide isolation valves (ball valves) for all fixtures.

.3 Connect plumbing fixtures and fittings with piping sized in accordance with the Drawing schedule.

.4 Confirm the exact location of all plumbing fixtures and trim prior to roughing-in.

.5 When installation is complete, check and test the operation of each fixture and fitting. Adjust or repair as required.

.6 Counter Mounted Fixtures and Trim: Supply templates for all counter mounted fixtures and trim and hand to the trade who will but the counter. Ensure openings in the counter are properly located.

.7 Electronic Lavatory Faucets: Locate control panels for electronic faucets under the lavatories and recessed into the wall. It is the intent to locate the transformer(s) (power converter(s)) in the wall cavity or concealed under counters. Provide access doors accordingly for servicing of transformer(s). Coordinate locations with the work of Division 26 that will provide 120 vac line supply to the transformers(s). Provide low voltage wiring from the transformer(s) to each terminal point in control panel(s) under lavatories. All water and electronic supply from control panel to faucet shall be through the flexible conduit supplied with the control panel. Connect hot and cold water piping to the mixing valve in each box, and tempered water piping from each mixing valve to the faucet. Set mixing valve maximum temperature limit stops to 43 ºC. (109 ºF) after potable water systems (hot and cold) are complete. Ensure that each programmable controller is properly programmed, and that water off after deactivation is set for three seconds. **Note:** All electrical line supply and low voltage wiring, including any wall receptacles as well as low voltage wiring to boxes shall be concealed.

.8 Electronic Flush Valves: Locate the transformer(s) (power converter(s)) in the wall cavity next to fixtures to be served. Provide access doors accordingly for servicing of transformer(s). Coordinate locations with Division 26 who will provide 120 vac line supply to the transformers(s). Provide low voltage wiring from the transformers(s) to each electronic flush valve terminal point. Note: All electrical line supply and low voltage wiring, including any wall receptacles as well as low voltage wiring to boxes shall be concealed.

.9 Thermostatic Mixing Valves: The device shall be designed to be installed at a single outlet. It may be used to supply individual outlets when there is sufficient supply pressure. Ball valves shall be installed on the hot and

cold inlet supplies. Temperature shall be field set. Maximum pressure differential shall be 103 kPa (15 psi) between hot and cold inlets. Integral check valves and strainer screen shall be installed on hot and cold supply.

3.2 Adjusting

.1 Adjust the water flow rate to design flow rates.

.2 Adjust the pressure to fixtures to ensure no splashing at maximum pressures.

.3 Checks:

.4 Aerators: Verify operation, cleanliness.

.5 Vacuum breakers, backflow preventers: Verify operation under all conditions.

.6 Thermostatic controls:

.7 Verify temperature settings, operation of control, limit and safety controls.

3.3 Fixture and specialty connection schedule

Tag	Description	Sanitary Waste mm (in.)	Sanitary Vent mm (in.)	DCWS mm (in.)	DHWS mm (in.)	Temp. mm (in.)	Comments
W-1	Barrier Free Wall Hung Flush Valve Water Closet	75 (3)	38 (1.5)	25 (1)	-	-	
W-2	General Use Wall Hung Flush Valve Water Closet	75 (3)	38 (1.5)	25 (1)	-	-	
W-3	Barrier Free Flush Tank Water Closet	75 (3)	38 (1.5)	13 (0.5)	-	-	
W-4	General Use Flush Tank Water Closet	75 (3)	38 (1.5)	13 (0.5)	-	-	
U-1	Barrier Free Wall Hung Flush Valve Urinal	50 (2)	38 (1.5)	19 (0.75)	-	-	

Tag	Description	Sanitary Waste mm (in.)	Sanitary Vent mm (in.)	DCWS mm (in.)	DHWS mm (in.)	Temp. mm (in.)	Comments
U-2	General Use Wall Hung Flush Valve Urinal	50 (2)	38 (1.5)	19 (0.75)	-	-	
L-1	Barrier Free Countertop Lavatory	32 (1.25)	32 (1.25)	13 (0.5)	13 (0.5)	13 (0.5)	
L-2	Barrier Free Wall Hung Lavatory	32 (1.25)	32 (1.25)	13 (0.5)	13 (0.5)	13 (0.5)	
S-1	Single Compartment Stainless Steel Sink	38 (1.5)	38 (1.5)	13 (0.5)	13 (0.5)	-	
S-2	Double Compartment Stainless Steel Sink	2@ 38 (1.5)	38 (1.5)	13 (0.5)	13 (0.5)	-	
S-3	Janitor's Service Sink	75 (3)	38 (1.5)	13 (0.5)	13 (0.5)	-	
DF-1	Barrier Free Drinking Fountain	32 (1.25)	32 (1.25)	13 (0.5)	-	-	
E-1	Emergency Eye/Face Wash	38 (1.5)	38 (1.5)	19 (0.75)	19 (0.75)	19 (0.75)	
FD	Floor Drain	75 (3)	38 (1.5)	9 (0.38)	-	-	DCWS from TSP
FFD	Funnel Floor Drain	75 (3)	38 (1.5)	9 (0.38)	-	-	DCWS from TSP
TD	Trench Drain	75 (3)	38 (1.5)	9 (0.38)			DCWS From TSP

Tag	Description	Sanitary Waste mm (in.)	Sanitary Vent mm (in.)	DCWS mm (in.)	DHWS mm (in.)	Temp. mm (in.)	Comments
FS-1	Floor Sink	100 (4)	38 (1.5)	-	-	-	
TSP	Trap Seal Primer	-	-	19 (0.75) *9 (0.38)	-	-	* per FD + FFD
WH-1	Exterior Non-Freeze Wall Hydrant	-	-	19 (0.75)	-	-	
WH-2	Interior Dual Temp. Wall Hydrant	-	-	19 (0.75)	-	-	
PH-1	Post Hydrant	-	-	19 (0.75)	-	-	

3.4 Cleaning and protection

.1 After completing the installation of fixtures, inspect and repair damaged finishes.

.2 Clean fixtures, faucets, valves and other fittings with the manufacturers' recommended cleaning methods and materials.

.3 Provide protective covering for installed fixtures and fittings.

.4 Do not allow the use of fixtures for temporary facilities unless approved in writing by the Owner.

End of section

1 General

1.1 Section includes

.1 Pipe and pipe fittings for:

.1 Heating water/glycol piping system.

.2 Chilled water/glycol piping system.

.3 Condenser water piping system.

.4 Equipment drains and overflows and Valves.

.5 Gate valves, Globe or angle valves.

.2 Valves

.1 Gate valves.

.2 Globe valves.

.3 Angle valves.

.4 Ball valves.

.5 Butterfly valves.

.6 Check valves.

.7 Circuit balancing valves (CBV).

.8 Drain valves.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 ANSI B18.2.1a – Square and Hex Bolts and Screws.

.2 ASME -Welding and Brazing Qualifications.

.3 ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800.

.4 ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.

.5 ASME B16.5 Pipe Pumps & Fittings.

.6 ASME B16.9, Factory Made Wrought Steel Buttwelding Fittings.

.7 ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

.8 ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

.9 ASME B31.5 - Refrigeration Piping and Heat Transfer Components.

.10 ASME B31.1 - Code for Power Piping.

.11 ASTM A53/A53M - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

.12 A183 Carbon Steel Track Bolts and Nuts.

.13 ASTM A234/A234M - Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and High Temperature Service.

.14 ASTM B32 - Solder Metal.

.15 ASTM B88 - Seamless Copper Water Tube.

.16 ASTM D1785 - Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

.17 ASTM D2235 - Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.

.18 ASTM D2241 - Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR-Series).

.19 ASTM D2310 - Machine-Made Fibreglass' (Glass Fibre-Reinforced Thermosetting Resin) Pipe.

.20 ASTM D2466 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

.21 ASTM D2467 - Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

.22 ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.

.23 ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.

.24 ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.

.25 ASTM D2855 - Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.

.26 ASTM D3309 - Polybutylene (PB) Plastic Hot-and Cold-Water Distribution Systems.

.27 ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

.28 ASTM F708 - Design and Installation of Rigid Pipe Hangers.

.29 ASTM F876 - Crosslinked Polyethylene (PEX) Tubing.

.30 ASTM F877 - Crosslinked Polyethylene (PEX) Plastic Hot - and Cold - Water Distribution Systems.

.31 AWS A5.8 - Filler Metals for Brazing and Braze Welding.

.32 AWS D1.1 - Structural Welding Code - Steel.

.33 AWWA C105 - Polyethylene Encasement for Ductile-Iron Pipe Systems.

.34 AWWA C110 - Ductile - Iron and Grey -Iron Fittings 3 in. – 48 in. (75 mm – 1200 mm), for Water and Other Liquids.

.35 AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Pressure Pipe and Fittings.

.36 AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast, for Water.

.37 MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacture.

.38 MSS-SP-67 - Butterfly Valves.

.39 MSS SP69 - Pipe Hangers and Supports - Selection and Application.

.40 MSS SP 70 - Cast Iron Gate Valves, Flanged and Threaded Ends.

.41 MSS SP 71 - Grey Iron Swing Check Valves, Flanged and Threaded Ends.

.42 MSS SP 80 - Bronze Gate, Globe, Angle and Check Valves.

.43 MSS SP 85 - Grey Iron Globe and Angle Valves, Flanged and Threaded Ends

.44 MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.

.4 Welders Certificate: Include welder’s certification of compliance with ASME SEC 9.

.5 Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.5 Quality assurance

.1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

.2 Installer: Company specializing in performing the work of this section with minimum three (3) years documented experience.

.3 Welders: Certified to ASME SEC 9.

1.6 Regulatory requirements

.1 Conform to ASME B31.9 code for installation of piping system.

.2 Welding Materials and Procedures: Conform to ASME SEC 9 and applicable provincial labour regulations.

.3 Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

1.7 Delivery, storage and protection

.1 Accept valves on site in shipping containers with labelling in place. Inspect for damage.

.2 Provide temporary protective coating on cast iron and steel valves.

.3 Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

.4 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.8 Environmental requirements

.1 Do not install underground piping when bedding is wet or frozen.

1.9 Extra materials

.1 Provide two (2) repacking kits for each size and valve type.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Pipe, fittings and joints

.1 50 mm (2 in.) and smaller.

.1 Mild black carbon steel, schedule 40, seamless, Grade B, ASTM A53, complete with Class 125 cast iron threaded fittings to ANSI/ASME B16.4 and screwed joints.

.2 Type L hard drawn seamless copper to ASTM B88 complete with soldered joints and fittings to ASTM B32, 95/5 either tin/antimony or tin/silver solder. Fittings to ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.

.2 65 mm (2½ in.) and larger.

.1 Mild black carbon steel, schedule 40, seamless, Grade B, ASTM A53, mill or site beveled, complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, long sweep pattern wherever possible, and welded joints.

.2 Flanges: ASTM A105, Class 150, raised face, weld neck or slip on.

.3 Bolts: ASTM A307 C.S. bolts, sq. head; ASTM A563 nuts, hex head

.4 Gaskets: 1.6 mm (1/16 in.) thick preformed non-asbestos graphite fibre

.3 Grooved Joint.

.1 Mild black carbon steel, Grade B, ASTM A53, factory or site roll grooved, complete with:

.1 Cast ductile iron grooved end fittings conforming to ASTM A536.

.2 Victaulic Style 07 "Zero-Flex", Victaulic Style 107 "QuickVic", Tyco Grinnell Style 772, Gruvlok Fig. 7401 "Rigidlok", Shurjoint Model Z07, or approved alternate rigid couplings for piping in the Mechanical Rooms and for piping risers, Victaulic Style 77, Tyco Grinnell Style 707, Gruvlok Fig. 700, Shurjoint Model 7707, or approved alternate standard flexible couplings for all other piping.

.3 Gaskets to be EPDM compound, rated -34 °C to +110 °C (-30 °F to +230 °F).

2.3 Piping unions

.1 Screwed steel piping: malleable iron, ground joint, brass to iron or bronze to bronze seat screwed unions and union elbows with a minimum pressure rating of 1,725 kPa (250 psi) steam at 260 °C (500 °F).

.2 Welded steel piping: forged carbon steel slip-on type raised face welding flange unions to ASTM A105,150 lb.

.3 Dielectric Unions: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.4 Valves

.1 General

.1 Conform to requirements of ANSI, ASTM, ASME, and applicable MSS standards.

.2 Provide valves of the same manufacturer where possible.

.3 Manufacturer's name and pressure rating clearly marked on body to MSS-SP-25.

.4 Valid CRN (Canadian Registration Number) required for each valve.

.5 Materials:

.1 Bronze: ASTM B62 or B61 as applicable

.2 Brass: ASTM B283 C3770

.3 Cast Iron: ASTM A126 Class B

.6 End Connections:

.1 Threaded ends: ANSI B1.20.1

.2 Flanged ends: ANSI B16.1 (Class 125), ANSI B16.5

.3 Face-to-face dimensions: ANSI B16.10

.7 Design and Testing:

.1 Bronze Gate & Check valves: MSS-SP-80

.2 Ball Valves: MSS-SP-110

.3 Cast Iron Gate Valves: MSS-SP-70

.4 Cast Iron Globe Valves: MSS-SP-85

.5 Cast Iron Check: MSS-SP-71

.6 Butterfly Valves: MSS-SP-67

.2 Isolation

.1 Ball Type: Class 600, 4,140 kPa (600 psi) WOG rated full port ball valves, each complete with a forged brass or bronze body and cap, blowout-proof stem, solid forged brass chrome plated ball, “Teflon” or “PTFE” seat, threaded ends, and removable lever handle. Where piping is insulated provide stem extensions to clear insulation.

.2 Acceptable products are:

.1 Kitz Corp. Code 58;

.2 Toyo Valve Co. Fig. 5044A;

.3 MAS B-3;

.4 Nibco #T-FP-600 or T-585-70;

.5 Victaulic Co. of Canada Ltd. Series 722;

.6 Anvil Fig. 171N;

.7 Watts Water Technologies (Canada) Inc. FBV-3; or

.8 Approved alternate.

.3 Butterfly

.1 Ductile iron, lug body style or grooved, 1,200 kPa (175 psi) rated, butterfly valve, each complete with a neck to permit 50 mm (2 in.) of insulation above the flange, an EPDM seat, aluminum bronze disc, stainless steel shaft with EPDM seal, a lever handle for valves to and including 100 mm (4 in.) diameter, and a handwheel and gear type operator for valves larger than 100 mm (4 in.) diameter and each suitable for bubble-tight dead end service with the valve in position and either side of the connecting piping removed. Where piping is insulated provide stem extensions to clear insulation.

.2 Acceptable products are:

.1 Kitz Corp Code No. 6122EL or 6122EG;

.2 Nibco #LD-2000 or GD-4765;

.3 Watts Water Technologies (Canada) Inc. #BF-M3;

.4 Toyo #918BESL2 or 918BESG2;

.5 Victaulic #VIC-300 Master Seal (Bronze Disc up to and including 150 mm (6 in.) and Stainless Steel Disc 200 mm (8 in.) and greater);

.6 Tyco Grinnell Model B-302; or

.7 Approved alternate.

.4 Swing Check

.1 Bronze – Screwed: Class 150, 2,070 kPa (300 psi) WOG rated horizontal swing check valves, each complete with a “Y” pattern bronze body, hinged brass disc, easy access screw-in cap, and screwed ends.

.2 Acceptable products are:

.1 Kitz Corp. Code No. 29;

.2 Toyo Valve Co. Fig. 238;

.3 Nibco #T-433; or

.4 Approved alternate.

.3 Steel – Grooved Ends: Victaulic Co. of Canada Ltd. Series 716 "Vic-Check", Tyco Grinnell Model 590, Gruvlok Series 7811 or Shurjoint #SJ-900 grooved end carbon steel check valves suitable for mounting horizontally or vertically; or approved alternate.

.4 Cast Iron – Flanged: Cast iron, bronze trim, 1,380 kPa (200 psi) rated swing check valves, each complete with a bronze disc and seat, malleable iron hinge, bolted cover, and flanged ends as required.

.5 Acceptable products are:

.1 Kitz Corp. Code No. 78;

.2 Toyo Valve Co. Fig. 435A;

.3 Nibco # T-918-B or FE-918-B;

.4 Watts Water Technologies (Canada) Inc. #F-511; or

.5 Approved alternate.

.5 Drain

.1 Minimum 2,070kPa (00 psi) WOG rated, 20 mm (¾ in.) straight pattern bronze or brass ball valves, each complete with a threaded outlet suitable for coupling connection of 19 mm (¾ in.) garden hose, and a cap and chain.

.2 Acceptable products are:

.1 Kitz Corp. Code No 68AC or 69AC;

.2 Toyo Valve Co. Ltd. Fig. 5046;

.3 Nibco #T-585-70-HC;

.4 Watts Regulator #B-6000-CC; or

.5 Approved alternate.

.6 Provide gear operator and chain on valves installed above 3.0 m (10 ft. 0 in.) above finished floor or greater.

2.5 Equipment drains and overflows

.1 Copper Tubing: ASTM B88, Type M and DWV, hard drawn.

.1 Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.

.2 Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 220 °C to 280 °C (428 °F to 536 °F).

2.6 Circuit balancing valves (CBV)

.1 Circuit Balancing Valves: 50 mm (2 in.) and smaller.

.1 Screwed connection, globe style design, nonferrous, pressure die-cast, nonporous Ametal Copper Alloy. Each valve shall be such that when installed in any direction, it will not affect flow measurement.

.2 Valves shall provide the following functions:

.1 Precise flow measurement.

.2 Precision flow balancing.

.3 Positive shut off with no drip seat and teflon disc.

.4 Drain connection with protective cap.

.3 Valves shall have four 360 ° adjustment turns of hand wheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision tamper-proof balancing setting.

.4 Valves shall be shipped in a 4.5 R factor polyurethane container that shall be used as insulation after valve in installed.

.5 Provide valves suitable for maximum working pressure of 1,720 kPa (250 psi) and maximum operating temperature of 121 °C (250 °F).

.6 Acceptable Products:

.1 S.A. Armstrong CRV I;

.2 Tour & Anderson STA-D;

.3 Oventropp; or

.4 Approved alternate.

.2 Circuit Balancing Valves: 65 mm (2½ in.) and larger.

.1 Flanged, line size connection, globe style design, nonferrous, pressure die-cast, nonporous Ametal Copper Alloy.

.2 Valves, shall provide the following functions:

.1 Precise flow measurement.

.2 Precision flow balancing.

.3 Positive shut off with no drip seat and teflon disc.

.3 Valves shall have twelve 360 ° adjustment turns of hand wheel for maximum vernier-type setting with "Hidden Memory" feature to program the valve with precision tamper-proof balancing setting.

.4 Valves shall be suitable for maximum working pressure of 1,720 kPa (250 psi) and maximum operating temperature of 120 °C (250 °F).

.5 Acceptable Products:

.1 S.A. Armstrong CBV II;

.2 Tour & Anderson STA-F;

.3 Oventropp; or

.4 Approved alternate.

2.7 Expansion joints

.1 Threaded, grooved or flanged expansion joints with multi-ply ASTM A240 T304 stainless steel bellows, A53 GRB carbon steel outer housing and anti-torque device. Each expansion joint is to be designed and detailed by the manufacturer. Submit shop drawings and calculations provided by the manufacturer for review.

.2 Acceptable products are:

.1 Senior Flexonics Ltd. Model “H2-MMT” 50 mm (2 in.) and smaller or Model “SX” 65 mm (2½ in.) and larger;

.2 Metraflex Model “HP2” 50 mm (2 in.) and smaller or Model “METRAGATOR” 65 mm (2½ in.) and larger;

.3 Hyspan Series “8500” 50 mm (2 in.) and smaller or Series “3500” 65 mm (2½ in.) and larger; or

.4 Approved alternate.

2.8 Alignment guides

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

.2 Acceptable products are:

.1 Senior Flexonics Ltd. Series PGT;

.2 Anvil Fig. 255;

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

.4 The Metraflex Co. Style IV;

.5 Hyspan Series 9500; or

.6 Approved alternate.

2.9 Anchors

.1 Welded structural black steel anchors of a size and type to securely anchor the pipe at the point shown. Each anchor is to be designed and detailed by a professional structural engineer registered in the Province of Ontario. Submit anchor shop drawings, stamped by the design engineer, for review.

3 Execution

3.1 Preparation

.1 Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

.2 Remove scale and dirt on inside and outside before assembly.

.3 Prepare piping connections to equipment with flanges or unions.

.4 Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

.5 After completion, fill, clean, and treat systems.

3.2 Applications

.1 Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

.2 Where permitted, install grooved mechanical couplings and fasteners in accessible locations.

.3 Install unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

.4 Provide non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

.5 Provide pipe hangers and supports to CSA B51 unless indicated otherwise.

.6 Use gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.

.7 Use globe valves for throttling, bypass, manual flow control services, for balancing and in bypass around control valves.

.8 Use spring loaded check valves on discharge of condenser water pumps.

.9 Use wafer check valves where required to suit space and or weight limitations.

.10 Use ¾ in. (19 mm) gate or ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

.11 Use lug end butterfly valves to isolate equipment.

.12 Butterfly valves may be used isolation and throttling duty for large pipe sizes 2½ in. (65 mm) and above.

.13 Gasket material shall be Grade 'E' EPDM compound conforming of ASTM D2-2000 and suitable for an operating temperature range of -34 °C to 110 °C.

.14 Small run outs, size ¾ in. (19 mm) and less for extension of domestic make-up piping may be constructed using hand drawn copper tube type 'K' or "L" and comply to ASTM B88.

3.3 Installation

.1 Install to manufacturer's instructions.

.2 Install heating water, glycol, chilled water, condenser water piping to CSA B51.

.3 Route piping in orderly manner, parallel to building structure, and maintain gradient.

.4 Install piping to conserve building space, and not interfere with use of space.

.5 Group piping whenever practical at common elevations.

.6 Sleeve pipe passing through partitions, walls and floors.

.7 Slope piping and arrange to drain at low points.

.8 Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

.9 Inserts:

.1 Provide inserts for placement in concrete formwork.

.2 Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

.3 Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 in. (100 mm).

.4 Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

.5 Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

.10 Pipe Hangers and Supports:

.1 Install to CSA B51.

.2 Support horizontal piping as scheduled.

.3 Install hangers to provide minimum ½ in. (13 mm) space between finished covering and adjacent work.

.4 Place hangers within 12 in. (300 mm) of each horizontal elbow.

.5 Use hangers with 1½ in. (38 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.

.6 Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.

.7 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

.8 Provide copper plated hangers and supports for copper piping.

.9 Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

.11 Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

.12 Provide access where valves and fittings are not exposed.

.13 Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

.14 Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer (VOC content not to exceed 100 g/L) to welds.

.15 Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

.16 Install valves with stems upright or horizontal, not inverted.

.17 Air vents shall be selected to suit the system operating pressures and shall be automatic and complete with isolating valves.

.18 All strainers 1½ in. (38 mm) & larger shall be fitted with chain valves.

.19 Unless specified otherwise, drain piping shall be sloped down in the direction of flow not less than 1 in. in 40 ft.

.20 Eccentric reducers shall be provided to keep the bottom of sloped piping aligned in order to minimize risk of water hammer and to facilitate drainage.

.21 Valves shall be installed with stems upright or angled 45 ° above horizontal unless instructed otherwise.

.22 Pipe all discharge from temperature and safety relief valves to a point of safe discharge directly into a floor drain, hub drain or safe outdoor location.

3.4 Equipment connections

.1 Install unions or flanges at connections to all equipment and specialty components.

.2 Arrange piping connections to allow ease of access and removal of equipment.

.3 Align and independently support piping adjacent to equipment connections in order to prevent piping stresses from being transferred to equipment.

.4 Piping reducers shall be used where equipment connections differ from pipe sizes indicated. The use of bushings will not be permitted.

.5 Install removable sections of pipe 12 in. (300 mm) spool pieces on the suction side of pumps and where needed for ease of maintenance.

3.5 Valves, cocks and faucets

.1 Use valves of line size unless noted otherwise.

.2 Provide isolating valves in each branch from the main line and where indicated.

.3 Provide isolating valves at all equipment connections.

.4 Provide globe valves or ball valves complete with memory stop at the discharge of each pump and where valves are used for regulating or throttling purposes.

.5 Provide ½ in. (13 mm) brass hose bibbs at all low points of each system, where the system cannot be drained through the main floor or return piping.

.6 Where new valves are installed to replace existing valves and it is impractical to shut-down and drain the entire system, valves shall be replaced using pipe freezing techniques.

3.6 Hydronic specialties

.1 Air Vents

.1 Provide 1 in. (25 mm) diameter air vent chamber at each riser feeding terminal units. Install chambers as high as possible within unit, and provide manual air vent connected to air chamber by flexible tubing.

.2 Provide a float type automatic air vent at any high points of hot water supply and return piping not vented through a convector etc. and at high point of piping for each hot water coil. The discharge of air vent shall terminate over a floor drain in mechanical rooms or over a sink in service rooms. A shut-off valve shall be provided on each automatic air vent and an access door and frame shall be provided for air vents located above ceilings.

.2 Automatic Feed Valves: provide automatic feed valve on the cold water make-up line to each new hot water heating system.

.3 Air Cushion Tanks

.1 Provide air cushion tanks of size noted where indicated.

.2 Provide housekeeping pad for floor mounting of tank.

.3 Terminate drain out line at nearest funnel floor drain, or service sink.

.4 Adjust charge to system static pressure at point of connection plus 5 psi (35 kPa).

.4 Air Eliminators: provide an air eliminator at each new air cushion (expansion) tank.

.5 Circuit Balancing Valve (CBV): provide a CBV in each branch serving a heating and/or cooling terminal unit and where indicated on drawings. Installation shall be in accordance with manufacturer's installation instructions. Ensure that manufacturer's recommended clearances are maintained to minimize turbulence and to promote accuracy.

.6 Supply and install threaded couplings or half coupling for flow switches that are supplied under Section 25 01 00 – Mechanical General Requirements.

.7 Install flow switches as supplied under Section 25 01 00 – Mechanical General Requirements.

3.7 Testing and inspection

.1 Test liquid heat transfer piping hydrostatically at not less than 150 % of operating pressure or not less than 125 psi (860 kPa) whichever is the greater. Test period shall be not less than six (6) hours duration during

which time each joint shall be inspected, given a sharp tap with a hammer and checked for leaks.

.2 Arrange and pay for inspection by authorities having jurisdiction.

3.8 Adjusting and balancing

.1 Instruments used for this work shall be accurately calibrated and maintained in good working order, and shall include:

.1 one set of pressure gauges and fittings.

.2 dry bulb thermometer.

.3 wet bulb thermometer.

.4 thermocouple unit and thermocouple.

.5 set of balancing cock adjustment wrenches.

.6 portable field flow meter.

.2 Prepare the liquid heat transfer systems as follows:

.1 Install any additional devices required for effective balancing as advised by the Systems Verification Agency.

.2 Open all valves, and return line balancing cocks.

.3 Remove and clean all strainers.

.4 Check pump rotation.

.5 Check expansion tanks to make sure they are not air bound and that the system is full of water.

.6 Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Make certain all air is removed from circulating system.

.7 Set all temperature controls so that all coils are calling for full cooling. This should close all automatic bypass valves at coil and chillers. To balance hot water coils, set systems to call for full heating.

.8 Check operation of automatic bypass valve.

.9 Check and set operating temperature of heat exchangers to design requirements.

.3 Balance the liquid heat transfer systems as follows:

.1 Complete air balance must have been accomplished before water balance is begun.

.2 Set chilled water, hot water and glycol pumps to proper flow rate delivery.

.3 Adjust flow of hot water through heat exchangers.

.4 Check leaving water temperatures and return water temperatures, and pressure drop through heat exchangers. Reset to correct design temperatures.

.5 Check water temperature at inlet side of cooling and heating coils. Note rise or drop of temperatures from source.

.6 Balance each chilled water and hot water coil.

.7 Upon completion of flow readings and coil adjustments, mark all settings and record all data.

.8 After making adjustments to coils, recheck settings at pumps, and heat exchangers. Readjust if required.

.9 Install pressure gauges on each coil, then read pressure drop through coil at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.

.10 Check and record the following items at each cooling and heating element:

.1 Inlet water and air temperature.

.2 Leaving water and air temperature.

.3 Pressure drop of each coil.

.4 Pump operating suction and discharge pressures and final total dynamic head.

.5 Pressure drop across bypass valve.

.6 All mechanical specifications of pumps.

.7 Rated and actual running amperage of pump motor.

.4 After completion of adjusting and balancing and submittal of records notify the Systems Verification Agency and the Consultant and assist in verifications. If systems fail verification, readjust and balance systems to the satisfaction of the Consultant.

End of section

1 General

1.1 Section includes

.1 Air vents

.2 Strainers

.3 Pressure relief valves

.4 Vortex air separators

.5 Expansion tanks

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 ASME - SEC 8D - Boilers and Pressure Vessels Code - Rules for Construction of Pressure Vessels.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

.4 Submit inspection certificates for pressure vessels from TSSA.

.5 Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.5 Quality assurance

.1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.6 Delivery, storage and protection

.1 Accept valves on site in shipping containers with labelling in place. Inspect for damage.

.2 Provide temporary protective coating on cast iron and steel valves.

.3 Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

.4 Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.7 Maintenance service

.1 Provide service and maintenance of glycol system for one (1) year from date of substantial completion.

.2 Monthly visit to make glycol fluid concentration analysis on site with refractive index measurement instrument. Detail findings with maintenance personnel in writing of corrective actions needed including analysis and amounts of glycol or water added.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Vortex air separator

.1 Vortex type vertical air separator with side tangential inlet and outlet connections, a top air outlet connection, and bottom drain connection. The separator is to be constructed of cast iron or fabricated steel for a

pressure of 1,105 kPa (160 psi) at 180 °C (350 °F) in accordance with Section VIII, Division I of the ASME Boiler and Pressure Vessel Code.

.2 Acceptable products are:

.1 S. A. Armstrong Ltd. Model “VA”;

.2 Bell & Gossett “Rolairtrol”; or

.3 Approved alternate.

2.3 Diaphragm type expansion tank

.1 Construction: Welded steel, tested and stamped to ASME SEC 8-D; supplied with National Board Form U-1, rated for working pressure of 125 psi (860 kPa), with flexible butyl diaphragm sealed into tank , and steel support stand.

.2 Accessories: Pressure gauge and air-charging fitting, tank drain; pre-charge to 11 psi (80 kPa).

.3 Automatic cold water fill assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.

.4 Refer to schedule on drawings.

.5 Acceptable products are:

.1 S. A. Armstrong Ltd. Series “AX-V” Series “L”;

.2 Bell & Gossett Series “B” (ASME);

.3 HG Specialties Inc. AL Series “Expanflex”; or

.4 Approved alternate.

2.4 Air vents

.1 Manual Type: Short vertical sections of 50 mm (2 in.) diameter pipe to form air chamber, with 3 mm brass needle valve at top of chamber. Apollo Valves (Johnson Paterson) 27-Series or approved alternate, 3.2 mm (⅛ in.) manual valve with key.

.2 Automatic Float Type: Float actuated air vents, either brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure:

.1 Acceptable products are:

.1 Spirax Sarco Ltd. type 13 WS for system working pressures to 1,035 kPa (150 psi), 13WH for system working pressures greater than 1,035 kPa (150 psi); or approved alternate.

.2 Armstrong International No. 1-AV Manufacturers:

.1 Amtrol;

.2 Taco; or

.3 Approved alternate.

2.5 Strainers

.1 Cast iron or bronze wye shaped strainers, minimum 860 kPa (125 psi) rated and complete with a removable type 304 stainless steel screen with perforations sized to suit the application, and for strainers 50 mm (2 in.) dia. and larger, a blowdown pipe connection tapping.

.2 Acceptable products are:

.1 Spirax Sarco Ltd. type IF-125 screwed or type AF-250 flanged;

.2 Toyo Valve Co. Ltd. Fig. 380A screwed or Fig. 381 flanged;

.3 Victaulic Co. of Canada Style 732 "Vic-Strainer";

.4 Tyco Grinnell Series S853 grooved wye strainer;

.5 Gruvlok series. 768G;

.6 Armstrong International Inc. A1 Series;

.7 Watts Water Technologies (Canada) Inc. #77SCI;

.8 Kitz Fig. 15 screwed or Fig. 80 flanged; or

.9 Approved alternate.

2.6 Pressure relief valves

.1 ASME tested, rated, and certified, bronze or cast iron bronze fitted, 1,035 kPa (150 psi) rated pressure relief valves, each capable of relieving the full output of the equipment it is associated with, and each factory set at 415 kPa (60 psi) unless otherwise specified.

.2 Acceptable products are:

.1 ITT Bell & Gossett 3301/4100, or 790/1170;

.2 Spirax Sarco Ltd. SVI Series;

.3 Conbraco 10-600 Series;

.4 Watts Water Technologies (Canada) Inc. 174A or 740; or

.5 Approved alternate.

3 Execution

3.1 Installation

.1 Install specialties to manufacturer's instructions.

.2 Where large air quantities can accumulate, provide enlarged air collection standpipes.

.3 Provide manual air vents at system high points and as indicated.

.4 For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain for water systems and to holding tank for glycol/water systems.

.5 Provide valved drain and hose connection on strainer blow down connection.

.6 Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.

.7 System relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

.8 Pipe relief valve outlet to nearest floor drain for water systems and to holding tank for glycol/water systems.

.9 Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

End of section

1 General

1.1 Section includes

.1 In-line circulators

.2 Vertical in-line pumps

.3 Side-stream filters

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 UL 778 - Motor-Operated Water Pumps.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.

.4 Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.

.5 Millwright's Certificate: Certify that base mounted pumps have been aligned.

1.5 Quality assurance

.1 Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum three (3) years experience.

.2 Alignment: Align base mounted pumps by qualified millwright.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

1.7 Performance requirements

.1 Ensure pumps operate at specified system fluid temperatures without vapour binding and cavitations, are non-overloading in parallel or individual operation, and operate within 25 % of midpoint of published maximum efficiency curve.

1.8 Extra materials

.1 Provide one (1) set of mechanical seals for each pumps.

.2 Provide two (2) sets of cartridges for each side-stream filter.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Manufacturer's

.1 ITT Bell & Gosset models indicated or approved alternate.

.2 Other acceptable manufacturers offering equivalent products. Subject to shop drawing review.

.1 S. A. Armstrong;

.2 Darling-Duro;

.3 Grundfos; or

.4 Approved alternate.

.3 Refer to schedule on drawings.

2.3 In-line circulators

.1 Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 125psi (860kPa) maximum working pressure.

.2 Casing: Cast iron, with flanged pump connections.

.3 Impeller: Cadmium plated steel, keyed to shaft.

.4 Bearings: Two (2), oil lubricated bronze sleeves.

.5 Shaft: Alloy or stainless steel with copper or bronze sleeve, integral thrust collar.

.6 Seal: Carbon rotating against a stationary ceramic seat, 225 °F (107 °C) maximum continuous operating temperature.

.7 Seal: Carbon rotating against a stationary ceramic seat, viton fitted, 275 °F (135 °C) maximum continuous operating temperature.

.8 Drive: Flexible coupling.

.9 Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code.

2.4 Vertical in-line

.1 Type: Vertical, single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 175 psi (1,200 kPa) working pressure.

.2 Casing: Cast iron, with suction and discharge gauge port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.

.3 Impeller: Bronze, fully enclosed, keyed directly to motor shaft or extension.

.4 Shaft: Carbon steel with stainless steel impeller cap screw or nut and bronze sleeve.

.5 Seal: Carbon rotating against a stationary ceramic seat, viton fitted, 225 °F (107 °C) maximum continuous operating temperature.

.6 Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes.

3 Execution

3.1 Installation

.1 Install to manufacturer's instructions.

.2 Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

.3 Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 in. (100 mm) and over.

.4 Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.

.5 Provide air cock and drain connection on horizontal pump casings.

.6 Provide drains for bases and seals, piped to and discharging into floor drains.

.7 Check, align, and certify alignment of base mounted pumps prior to start-up.

.8 Lubricate pumps before start-up.

.9 Provide side-stream filtration system for heating water systems. Install across pump with flow from pump discharge to pump suction from pump tappings.

End of section

1 General

1.1 Related Requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.2 References

.1 ASHRAE HANDBOOK, HVAC SYSTEMS & EQUIPMENT, Duct Construction Recommendations

.2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

- .1 HVAC Duct Construction Standards - Metal and Flexible
- .2 HVAC Duct Systems Design
- .3 Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
- .4 Accepted Industry Practice for Industrial Duct Design
- .5 HVAC Systems - Testing, Adjusting and Balancing
- .6 Round Industrial Duct Construction Standards
- .7 Rectangular Industrial Duct Construction Standards
- .8 HVAC Air Duct Leakage Test Manual.
- .9 Guide for Steel Stack Construction

.3 National Fire Protection Association (NFPA):

- .1 80 Standard for Fire Doors and Windows
- .2 90A Standard for Installation of AC and Ventilation Systems
- .3 90B Standard for Installation of Warm Air Heating and AC Systems
- .4 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- .5 255 Building Materials, Test of Burning Characteristics (same as ASTM E84)

.4 American Society for Testing and Materials (ASTM):

- .1 A90/A90M - Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.

.2 A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

.3 A480/A480M - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.

.4 A653/A653M - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

.5 A1011/A1011M - Standard Specification for Steel, Sheet, and Strip Hot-Rolled, Carbon, Structural, High-Strength, Low-Alloy with Improved Formability.

.6 B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

.7 A240 Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels

.8 A480 Standard Specification for General Requirements for Flat Rolled Stainless Heat-Resisting Steel Plate, Sheet and Strip

.9 A653 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot Dip Process.

.10 E84 Standard Test Method for Surface Burning Characteristics of Building Materials.

.11 E477 Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Material and Prefabricated Silencers.

.12 E814 Standard Test Method for Fire Tests of Through Penetration Fire Stops

.5 American Welding Society (AWS)

.1 B2.2 Brazing Procedures and Performance Qualifications

.2 D9.1 Sheet Metal Welding Code

.6 Underwriter's Laboratories (UL)

.1 181 Factory Made Air Ducts and Air Connectors

.2 555 Standard for Safety Fire Dampers

.3 555S Leakage Rated Dampers for Use in Smoke Control Systems

.4 723 Test for Surface Burning Characteristics of Burning Materials (ASTM E84)

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Shop drawings and product Data: data for duct materials.

.4 Submit changes or alterations in ductwork layout, with supporting calculations showing that the modified design will not increase total pressure, before work commences. Submittals for proposed changes shall be stamped for acceptance prior to commencement of work.

.5 Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

.6 Material Safety Data Sheets (MSDS) for sealants, adhesives and coatings.

.7 Manufacturer's Installation Instructions: Indicate special procedures for glass fibre ducts.

.8 Submit two samples of typical shop fabricated duct fittings.

1.4 Performance requirements

.1 No variation of duct configuration or sizes permitted except by written permission.

.2 Size round ducts installed in place of rectangular ducts to ASHRAE table of equivalent rectangular and round ducts.

.3 Sizes indicated on drawings are clear inside dimensions and do not include for duct linings.

1.5 Project record documents

.1 Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.6 Quality assurance

.1 Perform Work to SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

.2 Perform Duct Leakage Testing to SMACNA "HVAC Air Duct Leakage Testing Manual"

.3 Maintain one copy of document on site.

.4 Asbestos Free: Insulating and sealing materials must be certified to be free of asbestos.

.5 Brazing: Certify brazing procedures, brazers, and operators in accordance with AWS B2.2 Brazing Procedures and Performance Qualifications

.6 Welding: Certify welding procedures, welding equipment and welders in accordance with AWS D9.1 Sheet Metal Welding Code.

1.7 Regulatory requirements

.1 Ontario Building Code (OBC)

.2 Ontario Fire Code (OFC)

.3 Construct ductwork to NFPA 90A standards.

1.8 Environmental requirements

.1 Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.

.2 Maintain temperatures during and after installation of duct sealants.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Table of materials:

Application	Materials
Rigid HVAC ducts, casings and fittings	ASTM A653 galvanized steel sheet, lock form quality, G90 zinc coating (0.90 oz/ft.^{2}) to ASTM A90. Sheets free of pits, blisters, slivers, and ungalvanized spots.
Aluminium Ducts, dryer vents	ASTM B209; aluminium sheet, alloy 3003-H14. Aluminium Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength.

.2 Hanger Rod: continuously threaded, ASTM A36 galvanized steel in general, stainless steel for stainless steel ducts.

.3 Sealant: Non-hardening, water resistant, fire resistive, low VOC (VOC content not to exceed 50 g/L), compatible with mating materials; liquid used alone or with tape, or heavy mastic.

.4 Supports: Angle iron, channels, rods and related supporting materials shall be galvanized or red oxide coated.

.5 Fasteners: Use galvanized rivets, screws and bolts throughout, except on stainless steel ductwork, use SS fasteners.

.6 Reinforcements: Provide galvanized steel or stainless steel reinforcement shapes and plates to match ductwork.

.7 Tie Rods: Use galvanized steel, ¼ in. minimum diameter fasteners for ductwork 36 in. (900 mm) or less in length; use ⅜ in. minimum diameter for lengths longer than 36 in. (900 mm).

.8 Thickness, fabrication and reinforcement to SMACNA.

2.3 Duct construction

.1 Duct construction schedule:

Duct Application	Duct Pressure	Pressure Class (ins. wg.)	Seal Class	Leakage Class
Rectangular HVAC supply from AHU to terminal unit or reheat coil	Positive	4	A	6
Round HVAC supply from AHU to terminal unit or reheat coil	Positive	4	A	3
Rectangular HVAC single zone supply from unit to air outlet	Positive	2	A	6
Round HVAC single zone supply from unit to air outlet	Positive	2	A	3
Rectangular HVAC return from air inlet to AHU	Negative	2	A	6
Round HVAC return from air inlet to AHU	Negative	2	A	3
Rectangular sanitary exhaust ductwork	Negative	2	A	6
Round sanitary exhaust ductwork	Negative	2	A	3
Rectangular general HVAC exhaust	Negative	2	A	6
Round general HVAC exhaust	Negative	2	A	3
Exhaust fan discharge ductwork	Positive	2	A	0

.2 Note:

.1 Pressure class shall be the lower of the exhaust fan shut-off pressure or value shown.

2.4 Duct sealing

.1 Duct sealing schedule:

Seal Class	Sealing Requirements
A	All transverse joints, longitudinal seams and duct wall penetrations.
B	All transverse joints and longitudinal seams.
C	All transverse joints.

2.5 Duct leakage

.1 Leakage Class is defined as

$CL = F / (P)^{0.65}$

where: CL = Leakage Class

F = Leakage Factor (cfm/100 ft.^{2} of duct surface)

P = Static pressure in the duct (in.wg.)

.2 Table

Leakage Factor (F) CFM/100 ft.^{2} of duct surface					
Leakage Class	Pressure Class (ins.wg.) Positive or Negative				
C_L	1	2	4	6	10
12	12	19	30	38	54
6	6	9	15	19	27
3	3	5	7	10	13
0	0	0	0	0	0

2.6 Ductwork fabrication

.1 All Ductwork shall be constructed to withstand 1½ times fan pressure at shut-off and 2 in. (500 Pa) minimum.

.2 Fabricate and support to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated in accordance with recommendations of ASHRAE and SMACNA.

.3 Joints and reinforcements:

.1 to SMACNA and ASHRAE

.2 may be made with the Ductmate System or Nexus System or approved alternate. System components shall be made of standard catalogue manufacture as supplied by Ductmate Industries, Inc. or Nexus Inc. or approved alternate.

.4 Construct Tees, bends, and elbows with radius of not less than 1½ times width of duct on centreline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is

indicated, provide turning vanes of perforated metal with glass fibre insulation.

.5 Increase duct sizes gradually, not exceeding 15 ° divergence wherever possible; maximum 30 ° divergence upstream of equipment and 45deg. convergence downstream.

.6 Provide standard 45 ° lateral wye takeoffs. Alternative 90 ° conical tee connections may be used only where specifically indicated.

2.7 Round spiral lock seam ductwork

.1 Spiral ducts and elbows shall not be used for watertight exhaust systems.

.2 Ducts and fittings shall be manufactured from minimum G90 galvanized steel meeting ASTM A527/A527M-85.

.3 Ductwork shall be "Uni-Seal" or approved alternate, single wall, round spiral lock-seam type duct with wall thicknesses listed below.

.4 Fittings shall be "Uni-Form" or approved alternate, single wall, round fittings suitable for use with "Uni-Seal" or approved alternate, ductwork in wall thicknesses as follows:

Diameter ins. (mm)	Duct Metal Thickness ins. (Ga.) (mm)	Fitting Metal Thickness ins. (Ga.) (mm)
3-14 (75-350)	0.022 (26) (0.56)	0.028 (24) (0.70)
15-26 (375-650)	0.028 (24) (0.70)	0.034 (22) (0.86)
27-36 (675-900)	0.034 (22) (0.86)	0.040 (20) (1.00)
37-50 (925-1250)	0.040 (20) (1.00)	0.052 (18) (1.32)
52-60 (1300-1500)	0.052 (18) (1.32)	0.064 (16) (1.62)

.5 Acceptable Manufacturer: "Uni-Seal" spiral lock-seam duct and "Uni-Form" fittings as manufactured by United Sheet Metal or approved alternates. Other manufacturers subject to shop drawing review.

2.8 Flexible ductwork

.1 Flexible ducts shall be factory fabricated to CAN/ULC S110, factory fabricated assembly with a laminated inner liner of aluminum foil,

fibreglass and polyester, a galvanized steel helix coil formed to the inner liner, a fibreglass insulation blanket, and a polyethylene outer jacket. Flexible duct shall have a flame resistant rating of twenty five (25) or less and a smoke developed rating of fifty (50) or less.

Pressure Rating	Low and Medium ins. wg. (kPa)
Maximum positive pressure	6.0 (3.0)
Maximum negative pressure	4.0 (2.0)
Maximum velocity	4000fpm (20m/s)
Permeance	0.1perm
Operating temperature	-20F to 250F (-29C to121C)
Maximum thermal conductance	0.23BTU/Hr-F
Listed and labelled	Class 0 / Class 1
Flexmaster Type	5

.2 Accessories: conical spin-in collars with butterfly volume dampers for connections to ductwork, round rigid galvanized steel fittings fabricated to SMACNA Standards and ASHRAE recommendations, bridge and gear clamps.

.3 Alternate manufacturers are subject to shop drawing review.

2.9 Fire rated duct wrap

.1 Manufacturers:

.1 3M Canada Company Fire Master Duct Wrap 615;

.2 CL4 Fire Protection Thermal Insulation Quickwrap;

.3 Royal Quickstop; or

.4 Approved alternate, subject to shop drawing review.

.2 Ductwork required to be fire-rated shall be greater than or equal to the minimum gauge listed for the design no., G-90 galvanized steel, wrapped with 3M Fire Master Duct Wrap 615 or approved alternate, consisting of a 1½ in. (38 mm) thick non-combustible, flexible fireproof blanket, fully encapsulated in a foil scrim and supplied in roll form. The wrap material shall be applied directly onto the installed ductwork strictly in accordance

with the manufacturer's instructions and the ULC Listing and Design No., Guide No. 40 U21, 'Fire Resistant Ducts', as tested to ISO Standard 6944.

3 Execution

3.1 Installation

.1 Install and seal ducts to SMACNA HVAC Duct Construction Standards - Metal and Flexible.

.2 Install ductwork parallel to building lines.

.3 Support all ductwork from structural members. Where structural bearings do not exist, suspend strapping or hangers from steel channels or angles. Provide supplementary structural members. Do not suspend from metal deck.

.4 Do not break continuity of insulation vapour barrier by hangers or rods.

.5 Hangers shall be steel angles with supporting rods, locking nuts and washers to following table:

Duct Size ins. (mm)	Angle Size ins. (mm)	Rod Size ins. (mm)	Spacing ft. (mm)
<30 (750)	1x1x1/8 (25x25x3)	1/4 (6)	10.0 (3000)
31-42 (775-1050)	1-1/2x1-1/2x1/8 (38x38x3)	1/4 (6)	10.0 (3000)
43-60 (1050-1500)	1-1/2x1-1/2x1/8 (38x38x3)	3/8 (9)	10.0 (3000)
61-84 (1525-2100)	2x2x1/8 (50x50x3)	3/8 (9)	8.0 (2400)

.6 Vertical ducts passing through floors shall be supported on angles secured to duct bearing on the floor.

.7 Where ducts pass through walls, floors, openings required to have a fire resistance rating the opening in the construction around the duct shall be filled with an approved fire stop material as per NFPA 90A and fire damper shall also be installed with access doors as per the code.

.8 Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.

.9 Provide openings in duct work where required to accommodate thermometers and controllers. Provide pilot tube openings where required

for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

.10 Support risers in accordance with SMACNA.

.11 Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

.12 Use crimp joints with or without bead for joining round duct sizes 8" (200mm) and smaller with crimp in direction of air flow.

.13 Use double nuts and lock washers on threaded rod supports.

.14 Connect terminal units to supply ducts directly or with 12 in. (300 mm) maximum length of flexible duct. Do not use flexible duct to change direction.

.15 Connect diffusers or light troffer boots to low pressure ducts directly or with 60 in. (1.5 m) maximum length of flexible duct held in place with strap or clamp.

.16 Connect flexible ducts to metal ducts with adhesive and metal or nylon straps.

.17 Ground across flexible connector with No. 2/0 braided copper strap.

.18 During construction provide temporary closures of metal or taped polyethylene on open duct work to prevent construction dust from entering duct work system.

.19 Balancing dampers shall be installed on branches as per locations shown on the drawings and as per the requirements of NEBB and AABC listing/measuring standards.

.20 Perform duct leakage testing for all ductwork installed under this contract.

.21 Paint all visible internal portions of duct outlets to grilles dull black. Internal painting of ductwork behind grilles shall be by Sheet Metal Contractor.

.22 Seams and penetrations in ductwork and plenums shall be sealed in accordance with seal classifications as described in SMACNA and ASHRAE.

.23 Do not begin air balance until system has been completed and is in full working order. Put all heating, ventilating, and air conditioning system and

equipment into full operation and continue the operation of same during each working day of balancing procedures. Provide assistance to the Testing and balancing Agency as required.

3.2 Watertight ductwork

.1 Sprial ducts and elbows shall not be used for watertight exhaust systems.

.2 Provide watertight ductwork for:

- .1 Cartwasher exhaust
- .2 "Wet" air exhaust
- .3 Humidifiers for 10ft. (3metres) in all directions
- .4 Fresh air intake ducts and plenums

.3 Form bottom of duct without longitudinal seams.

.4 All seams and joints welded. Connections to equipment and accessories flanged and gasketed.

.5 Slope horizontal branch ductwork down toward hood or equipment served.

.6 Slope header ducts down toward risers.

.7 Fit base of risers with 6 in. (150 mm) deep drain and 1¼ in. (32 mm) drain connection, with deep seal trap and valved drain line to open funnel drain.

3.3 Corridor penetration ductwork

.1 Site measurements shall be taken before fabrication in the factory shall begin.

.2 The ductwork, joints, hangers, access doors and all other accessories shall be manufactured and installed as per manufacturer's instructions and in accordance with the ULC listing, meeting the requirements of NFPA 96.

.3 The final installation shall be inspected and approved by the duct manufacturer. Contractor to submit letters from manufacturer to authority having jurisdiction verifying undertaking to inspect and final approval.

3.4 Fire rated duct wrap

.1 Ductwork required to be fire-rated shall be minimum 24 ga., G-90 galvanized steel, wrapped with 3M Fire Master Duct Wrap 615 or approved alternate, consisting of a 1½ (38 mm) thick non-combustible,

flexible fire proof blanket, fully encapsulated in a foil scrim and supplied in roll form. The wrap material shall be applied directly onto the installed ductwork strictly in accordance with the manufacturers instructions and the ULC Listing and Design No., Guide No. 40 U21, 'Fire Resistant Ducts', as tested to ISO Standard 6944.

.2 Duct construction shall be as per ASHRAE and SMACNA using water tight construction. Hangers shall be threaded steel rod and angle iron cradles.

.3 One layer of wrap shall be applied to ductwork requiring a one (1) hour fire resistance rating and two layers shall be applied to ductwork requiring a two (2) hour fire resistance rating. Seams and joints to be lapped minimum 3 in. (75 mm), taped and secured with steel banding. Tape and banding to comply with ULC listing and manufacturer's instructions.

.4 All hangers, support rods, concrete anchors and fire stopping of duct penetrations through fire separations shall be in accordance with the ULC Listing and the manufacturer's instructions.

3.5 Flexible ductwork

.1 Flexible ductwork may be installed for final connections to air outlets provided that not more than 60 in. (1,500 mm) in length is used for each connection, and where specifically indicated on drawings.

.2 All fittings used with flexible ductwork shall be rigid round duct.

.3 Use pre-insulated flexible ductwork where application is to be insulated.

3.6 Duct cleanliness

.1 All ductwork shall be handled and installed in accordance with the advanced level described in SMACNA Duct Cleanliness for New Construction Guidelines.

.2 After completing system installation including outlet fittings and devices, inspect the system.

.3 Ductwork leaving the premises of the manufacturer may include some or all of the following:

.1 self-adhesive labels or marking for part(s) identification shall be applied to external surfaces only;

.2 exposed mastic sealant;

.3 light zinc oxide coating on the metal surface;

.4 a light coating of oil on machine formed ductwork;

.5 minor protrusions into the airway of rivets, screws, bolts and other jointing devices;

.6 internal insulation and associated fasteners;

.7 discoloration marks from plasma cutting process.

.8 to maintain cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping. Care must be taken to prevent damage during transportation and off loading.

.4 A clean and dry environment where the ductwork is protected from dust, must be provided for the storage of ductwork prior to installation. All sealed ends shall be visually examined and if damaged resealed with an appropriate material.

.5 During installation, the working area shall be clean, dry and the ductwork protected from dust.

.6 The internal surfaces of the un-insulated ductwork shall be wiped to remove excess dust immediately prior to installation.

.7 Open ends on completed ductwork and overnight work-in-progress shall be sealed.

.8 Access covers shall be firmly fitted in position on completion of each section of the work.

.9 Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

3.7 Duct leakage testing

.1 Ductwork shall be leak tested in accordance with the SMACNA "HVAC Air Duct Leakage Test Manual". The maximum permitted duct leakage shall be determined by multiplying the leakage factor by the surface area of the ductwork in the test zone.

.2 Ductwork that exceeds the maximum permitted leakage shall be re-sealed and re-tested.

.3 Duct leakage test shall be witnessed and certified by the Systems Verification Agency.

.4 Record and submit three (3) copies of test results to the Consultant for review prior to application of duct insulation or concealment of ductwork.

End of section

1 General

1.1 Section includes

.1 Air turning devices/extractors.

.2 Back draft dampers.

.3 Duct access doors.

.4 Duct test holes.

.5 Fire dampers.

.6 Combination Fire/Smoke Dampers.

.7 Flexible duct connections.

.8 Volume control dampers.

.9 Duct lining

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

.2 NFPA 92A - Smoke-Control Systems.

.3 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

.4 UL 33 - Heat Responsive Links for Fire-Protection Service.

.5 UL 555 - Standard for Fire Dampers.

.6 UL 555S - Standard for Smoke Dampers

.7 CAN/ULC-S112 - Fire Test of Fire-Damper Assemblies.

.8 CAN/ULC-S112.1 - Leakage Rated Dampers for Use in Smoke Control Systems.

.9 CAN/ULC-S112.2 - Fire Test of Ceiling Firestop Flap Assemblies.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit a ‘Letter of Conformance’, indicating the specified items selected for use in this Project with the following supporting product data reports.

.4 Shop Drawings for shop fabricated assemblies including balancing dampers, volume control dampers, duct access doors and duct test holes.

.5 Product Data for shop fabricated assemblies including volume control dampers, duct access doors, duct test holes and hardware used. Include electrical characteristics and connection requirements.

.6 Manufacturer's Installation Instructions for fire dampers.

1.5 Regulatory requirements

.1 Products Requiring Electrical Connection: CSA Listed as suitable for the purpose specified and indicated.

1.6 Delivery, storage and protection

.1 Transport, handle, store, and protect products.

.2 Protect dampers from damage to operating linkages and blades.

1.7 Extra materials

.1 Provide two (2) of each size and type of fusible link.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Air turning devices / extractors

.1 Turning vanes in rectangular duct elbows shall be double walled, multi-blade vanes with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps. Acceptable Products: Duro-Dyne "Duro Vane Rail", Hart & Cooley "Ducturn", Dyn-Air or Tuttle and Bailey, or approved alternate.

.2 Volume extractors: gang operated curved blades, adjustable from full open to full closed positions. Units shall be factory assembled, fabricated from 14 ga. and 22 ga. (2 and 0.9 mm) steel, with blades on 1 in. (25 mm) centres, and No. 2 or No. 3 operators to suit application. Acceptable Products: Krueger model EX-8 indicated. EH Price Model AE1, Duro-Dyne, Dyn-Air or Hart & Cooley, or approved alternate.

2.3 Back draft dampers

.1 Gravity back draft dampers, Size 18 in. x 18 in. (450 x 450 mm) or smaller, provided with air moving equipment: Air moving equipment manufacturers standard construction.

.2 Multi-blade, parallel action gravity balanced back draft dampers: 1/16 in. (1.5 mm) thick galvanized steel, or, with centre pivoted blades of maximum 6 in. (150 mm) width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 ° stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.4 Volume control dampers

.1 Factory fabricated with recognized hardware and accessories and to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

.2 Splitter Dampers:

.1 Material: Same gauge as duct to 24 in. (600 mm) size in either direction, and two (2) gauges heavier for sizes over 24 in. (600 mm).

.2 Blade: Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.

.3 Operator: Minimum 24 in. (600 mm) diameter rod in self aligning, universal joint action, flanged bushing with set screw.

.3 Single Leaf Dampers: fabricated from minimum 20 gauge (1.0 mm) galvanized steel, suitably reinforced to prevent vibration and fitted with indicating regulator. Duro-Dyne, Lawson & Taylor, Dyn-Air, or approved alternate.

.4 Multi-Blade Opposed Action Dampers: fabricated from 16 gauge (1.6 mm) galvanized steel, mounted in separate channel frames, reinforced to prevent vibration, and fitted with opposed action linkage hardware. Duro-Dyne "Opax" blade kit, Lawson & Taylor, Dyn-Air, or approved alternate.

.5 End Bearings: Except in round ductwork 12 in. (300 mm) and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

.6 Quadrants:

.1 Provide locking, indicating quadrant regulators on single and multi-blade dampers.

.2 On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

.3 Where rod lengths exceed 30 in. (750 mm) provide regulator at both ends.

2.5 Fire dampers

.1 Manufacturers:

.1 Ruskin;

.2 Nailor; or

.3 Approved alternate, subject to shop drawing review.

.2 Fire dampers shall be ULC listed, labelled, meet all requirements of NFPA 90A, and constructed and rated in conformance with:

.1 CAN/ULC-S112, "Fire Test of Fire-Damper Assemblies", when used in a fire separation of not more than three (3) hours.

.2 CAN/ULC-S112.2, "Fire Test of Ceiling Firestop Flap Assemblies", when used in a ceiling fire separation.

.3 Fire dampers shall be galvanized steel channel frame curtain type galvanized steel interlocking blades, minimum 22 gauge (0.9 mm) galvanized steel enclosure, and 160 °F (71 °C) fusible link standard.

.4 Fire dampers for horizontal installation in vertical ductwork shall be operated by a stainless steel closure spring and latch.

.5 Fire damper configuration shall be low resistance type B with blades located outside of the air stream for rectangular ductwork, and type C for round or oval ductwork.

.6 Ceiling fire dampers shall be ULC labelled, for fire rated membrane type ceilings, galvanized steel construction with heat retardant blanket (non-asbestos) with standard 160 °F (71 °C) fusible link.

.7 Thermal blanket shall be ULC labelled, for fire rated membrane type ceilings, to completely enshroud ceiling penetration.

.8 Fusible Links: UL 33, separate at 160 °F (71 °C) with adjustable link straps for combination fire/balancing dampers.

.9 Fire dampers listed for static systems shall be provided in ductwork where no air flow through the damper is expected such as in ductwork in HVAC systems that are automatically shut down in the event of a fire or for air transfer openings in walls or partitions.

.10 Fire dampers listed for dynamic systems shall be provided in ductwork where the airflow is operational at the time of fire.

2.6 Combination Fire/Smoke Dampers

.1 Manufacturers:

.1 Nailor, Series 1220;

.2 Ruskin;

.3 Approved alternate, subject to shop drawing review.

.2 Combination Fire/Smoke dampers shall be ULC listed, labelled, meet all requirements of NFPA 90A, and constructed and rated in conformance with:

.1 CAN/ULC-S112, "Fire Test of Fire-Damper Assemblies", labelled for 1-1/2 hr.

.2 UL-555 “Fire Damper” and UL-555S, “Smoke Dampers”, Leakage Class I at 250F(121C) elevated temperature.

.3 UL 268A Listed Smoke-automatic Detectors.

.4 AMCA Publication 511 and Pressure drop tested per AMCA Standard 500-D.

.3 Combination Fire/Smoke dampers shall be 16 gauge (1.6mm) galvanized steel channel frame with 14 gauge (2mm) galvanized steel opposed action interlocking double-skin airfoil blades, UL Classified ERL (Electric Resettable Link) heat responsive device set at 250F (121C), type-B factory sleeve enclosure minimum 500mm (20in) long caulked to UL requirements, retaining angles

.4 UL Listed Electric Actuator Belimo FSLF120 or approved alternate, on/off Fire/Smoke damper actuator with 120VAC power supply, spring return and auxiliary switch.

.5 UL Listed Factory mounted DSD-NF duct smoke detector or approved alternate, Photoelectronic type for no-flow condition, with 120VAC power supply and RA100ZA Remote Annunciator.

.6 Combination Fire/Smoke dampers listed for dynamic systems shall be provided in ductwork.

2.7 Duct access doors

.1 Fabricate doors airtight and suitable for duct pressure and to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

.2 Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated duct work, install minimum 1 in. (25 mm) thick insulation with sheet metal cover.

.1 Less Than 12 in. (300 mm) Square: Secure with sash locks.

.2 Up to 18 in. (450 mm) Square: Provide two (2) hinges and two (2) sash locks.

.3 Up to 24 in. x 48 in. (600 x 1,200 mm): Three (3) and two (2) compression latches with outside and inside handles.

.4 Larger Sizes: Provide an additional hinge.

.3 Access doors with sheet metal screw fasteners are not acceptable.

2.8 Duct test holes

.1 Provide test ports to suit intended application, (i.e. Insulated / un-insulated duct, round/rectangular duct).

.2 Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

.3 Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

.4 Acceptable Products: Air Power Co. Dial 1000, Dial 2000 or Duro-Dyne IP-1, IP-2, IPG-3, IP-4, Dyne-Air, or approved alternate.

2.9 Flexible duct connectors

.1 Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

.2 Connector: Fabric crimped into metal edging strip.

.1 Fabric: UL listed fire-retardant neoprene coated woven glass fibre fabric to NFPA 90A, minimum density 1.0 kg/m^2.

.2 Net Fabric Width: Approximately 2 in. (50 mm) wide.

.3 Metal: 3 in. (75 mm) wide, 1/32 in. (0.6 mm) thick.

2.10 Hangers and supports

.1 Fabricate strap hangers to same material as duct. Hanger configuration to SMACNA details. 20 in. (500 mm) is maximum duct size to be supported by strap hanger.

.2 Rod and angle hangers: galvanized steel to SMACNA details.

.3 Hanger attachments: manufactured concrete inserts, expansion shields and bolted steel clamps. Do not weld rods to steel decks or use powder actuated fasteners.

2.11 Fire protection duct wrap

.1 Ductwork required to be fire-rated shall be wrapped with 3M Fire Master Duct Wrap or approved alternate consisting of a 38 mm (1½ in.) thick non-combustible, flexible fireproof blanket, fully encapsulated in a foil scrim

and supplied in roll form. The wrap material shall be applied directly onto the installed ductwork Guide No. 40 U21, 'Fire Resistant Ducts', as tested to ISO Standard 6944. Also acceptable: Royal Quick-stop, CL4 Fire Protection Thermal Insulation Quick-wrap, or approved alternate.

2.12 Duct lining

.1 Fibre free duct lining.

2.13 Firestats

.1 Manual reset safety devices designed to break line or control voltage contact for fans as air temperature reaches a predetermined level.

.2 Acceptable Products: Honeywell #L4029F, Johnson Controls, Siemens, or approved alternate.

2.14 Duct sealant

.1 General: Low VOC, water based sealant, non-toxic, non-combustible, non-flammable, and tested in accordance with CAN4-S102-M18. Flame spread shall not exceed twenty five (25) and smoke developed shall not exceed fifty (50).

.2 Acceptable Products: Duro Dyne SWB Duct Sealer, Iron Grip 601 as supplied by Alpha Sheet Metal Co., Uni-Grip Duct Sealer from United McGill Corporation, or approved alternate.

3 Execution

3.1 Preparation

.1 Verify that electric power is available and of the correct characteristics.

3.2 Installation

.1 Install accessories to manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 – Ductwork for duct construction and pressure class.

.2 Provide back draft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

.3 Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 8 in. x 8 in. (200 x 200 mm) size for hand access, 18 in. x 18 in. (450 x 450 mm) size for shoulder access, and as indicated. Provide 4 in. x 4 in. (100 x 100 mm) for balancing dampers only. Review locations prior to fabrication.

.4 Provide duct test holes where indicated and required for testing and balancing purposes.

.5 Provide fire dampers , combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components , and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

.6 Install smoke dampers and combination smoke and fire dampers to NFPA 92A.

.7 Demonstrate re-setting of fire dampers to Owner's representative.

.8 Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment, and supported by vibration isolators. For fans developing static pressures of 1,250 Pa and over, cover connections with loaded vinyl sheet, held in place with metal straps.

.9 Use splitter dampers only where indicated.

.10 Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

.11 Install control dampers supplied under Section 25 01 00 – Controls in ducts or plenums as indicated.

.12 Install duct type smoke detectors in accordance with manufacturer’s instructions where required in Section 25 01 00 – Controls and in Division 26.

.13 Provide turning vanes where space restrictions prohibit the use of elbows having a minimum inside radius equal to the duct width for horizontal elbows or the duct depth for vertical elbows.

.14 Provide test ports as required by Balancing Agency and at inlet and outlet of fans, to completely test and balance the system. No temporary holes will be permitted in ductwork or flexible connections.

3.3 Fire dampers and Combination Fire/Smoke dampers

.1 Provide fire dampers where shown on drawings. In general, fire dampers are required where ducts pass through fire rated assemblies, floors and roofs and ducts entering and leaving duct shafts and mechanical rooms.

.2 Install fire dampers in strict accordance with manufacturer's installation instructions and in conformance with NFPA 90A.

.3 Install type B fire dampers for rectangular ductwork.

.4 Install type C fire dampers for round or oval ductwork.

.5 Openings for fire dampers must be properly prepared and the fire dampers installed, and secured prior to field review by the Consultant. Notify the Consultant when ready for review. Do not make any duct connections to fire dampers until review is complete and work found correct.

.6 Support fire dampers from building structure. Submit erection drawings, approved by all authorities, showing the locations and construction details of all fire dampers before proceeding with any work.

.7 Install ceiling fire dampers where ducts serve grilles and diffusers in rated ceilings. Support from building structure.

.8 Install thermal blanket in all fire rated membrane type ceilings. Thermal blanket shall be wrapped and stapled around the unexposed perimeter of diffuser after installation of ceiling damper following manufacturer's installation instructions.

.9 Damper actuators and smoke detectors of Combination Fire/Smoke Dampers shall be field wired to the Fire Alarm Control Panel. Refer to Division 26.

3.4 Duct access doors

.1 Provide duct access doors of suitable size in ductwork in the following locations:

.1 Suction inlet of all fans

.2 At not more than 12 m intervals

.3 At not more than 6 m intervals on the ductwork installed after a high efficiency filter

.4 At the base of all main risers

.5 In front of and behind all turning vanes and coils

.6 At all fire, smoke, and motorized dampers

.7 At all locations having an internally mounted piece of equipment or device. Provide a section of transparent plexi-glass to permit viewing without opening the access doors

.8 Where required for duct cleaning.

.2 Wherever possible, doors shall be mounted to close in direction of air flow.

3.5 Fire protection duct wrap

.1 Supply and install fire protection duct wrap on ductwork as indicated on drawings in accordance with manufacturers recommendations.

3.6 Duct lining

.1 Line internal surfaces of all ductwork, shown cross hatched on drawings with 1 in. (25 mm) thick duct lining. Butt joints tightly together.

.2 Adhere lining to all sides of duct with minimum 50 % coverage of flame resistant adhesive. Impale lining over welded pins on 12 in. (300 mm) centres at top sections and sides and secure with speed washers.

.3 Repair damage to neoprene compound coating on duct liner incurred during installation by spraying or brush coating with approved similar compound.

.4 No allowance has been made in duct sizes indicated for internal lining. Increase duct size 1 in. (25 mm) all around where lining is to be internally applied.

3.7 Firestats

.1 Provide 135 °F (57 °C) firestats in return air ductwork of all supply units greater than 2,000 CFM capacity.

.2 Provide 135 °F (57 °C) firestats in all exhaust systems greater than 2,000 CFM capacity.

.3 Provide 235 °F (112 °C) firestats in discharge of all supply air units greater than 2,000 CFM capacity.

.4 Wire firestats under this Section unless indicated otherwise in Mechanical-Electrical Schedule.

.5 Provide firestats in accordance with NFPA 90A.

End of section

1 General

1.1 Section includes

.1 Duct Silencers.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 AABC - National Standards for Total System Balance.

.2 AMCA 300 - Reverberant Room Method for Sound Testing of Fans.

.3 AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

.4 AMCA 302 - Application of Sone Ratings for Non-Ducted Air Moving Devices.

.5 AMCA 303 - Application of Sound Power Level Ratings for Fans.

.6 ANSI S1.1 - Acoustical Terminology.

.7 ANSI S1.8 - Preferred Reference Quantities for Acoustical Levels.

.8 ANSI S1.13 - Measurement of Sound Pressure Levels in Air.

.9 ARI 270 - Sound Rating of Outdoor Unitary Equipment.

.10 ARI 575 - Measuring Machinery Sound within an Equipment Space.

.11 ASA 16 (ANSI S1.36) - Survey Methods for Determination of Sound Power Levels of Noise Sources.

.12 ASA 47 (ANSI S1.4) - Specification for Sound Level Meters

.13 ASA 49 (ANSI S12.1) - Preparation of Standard Procedures to Determine the Noise Emission from Sources.

.14 ASHRAE 68 - Laboratory Method of Testing to Determine the Sound Power in a Duct.

.15 ASHRAE Handbook - Systems Volume, Chapter "Sound and Vibration Control".

.16 ASTM E90 - Method for Laboratory Measurement of Airborne Sound Transmission loss of Building Partitions and Elements.

.17 ASTM E477 - Method of Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.

.18 ASTM E596 - Method for Laboratory Measurement of Noise Reduction of Sound-Isolating Enclosures.

.19 NEBB - Procedural Standards for Measuring Sound and Vibration.

.20 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Shop Drawings: Indicate assembly, materials, thicknesses, dimensional data, pressure losses, acoustical performance, layout, and connection details.

.4 Product Data: Provide catalogue information indicating, materials, dimensional data, pressure losses, and acoustical performance.

.5 Design Data: Provide engineering calculations, referenced to specifications and AMCA 301 standards indicating that maximum room sound levels are not exceeded.

.6 Test Reports: Indicate dynamic insertion loss and noise generation values of silencers.

.7 Manufacturer's Installation Instructions: Indicate installation requirements which maintain integrity of sound isolation.

.8 Manufacturer's Field Reports: Indicate installation is complete and to instructions.

1.5 Performance requirements

.1 Maintain sound level of spaces at levels not to exceed those listed below by utilizing acoustical devices.

.2 Maintain rooms at following maximum sound levels, in Noise Criteria (NC) as defined by ASHRAE Handbook;

.1 Executive Offices: twenty five (25)

.2 Conference rooms: twenty five (25)

.3 Private Offices: thirty (30)

.4 Open-plan areas: thirty five (35)

.5 Computer/business machine areas: forty (40)

.6 Public circulation: forty (40)

1.6 Submittals

.1 Shop Drawings: Indicate assembly, materials, thicknesses, dimensional data, pressure losses, acoustical performance, layout, and connection details.

.2 Product Data: Provide catalogue information indicating, materials, dimensional data, pressure losses, and acoustical performance.

.3 Design Data: Provide engineering calculations, referenced to specifications and AMCA 301 standards indicating that maximum room sound levels are not exceeded.

.4 Test Reports: Indicate dynamic insertion loss and noise generation values of silencers.

.5 Manufacturer's Installation Instructions: Indicate installation requirements which maintain integrity of sound isolation.

.6 Manufacturer's Field Reports: Indicate installation is complete and to instructions.

.7 Quality assurance:

.1 Perform Work to AMCA 300 standards and recommendations of ASHRAE 68.

.2 Maintain one (1) copy of each document on site.

1.7 Qualifications

.1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

.2 Design application of duct silencers under direct supervision of a Professional Engineer experienced in design of this work and licensed at the place where the Project is located.

1.8 Regulatory requirements

.1 Conform to applicable code for sound levels at property line.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Duct silencers

.1 Manufacturers:

.1 Vibro-Acoustics;

.2 Kinetics Noise Control;

.3 Vibron;

.4 IAC Acoustics; or

.5 Approved alternates subject to shop drawing review.

.2 Description: Duct section with sheet metal outer casing, sound absorbing fill material, and inner casing of perforated sheet metal; incorporating interior baffles of similar construction. Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible.

.3 Performance: as scheduled

.4 Materials:

.1 Outer Casing: Minimum 1/32 in. (0.8 mm) thick galvanized steel stiffened as required, with mastic filled lock formed seams, 2 in. (50 mm) long, ⅛ in. (2.9 mm) slip joints on both ends.

.2 Inner Casing and Splitters: Minimum 1/32 in. (0.6 mm) thick perforated galvanized steel.

.3 Fill: Glass fibre or mineral wool of minimum 4 lb./ft.^{2} (64 kg/m^3) density.

.4 Fill Liner: Bonded glass fibre matting.

2.3 Ductwork lagging

.1 Acoustic Insulation: 2 in. (50 mm) thick, 50 to 80 kg/m^3 density glass fibre or mineral wool insulation.

.2 Covering: Sheet lead with surface weight minimum 4 lb./ft.^{2} (20 kg/m^2).

3 Execution

3.1 Installation

.1 Install to manufacturer's instructions.

.2 Support duct silencers independent of duct work with flexible duct connections, lagged with leaded vinyl sheet on inlet and outlet.

.3 Install cross-talk silencers in wall. Caulk wall penetrations, VOC content of caulking not to exceed 50 g/L.

.4 Lag duct work, where indicated by wrapping with insulation and covering. Apply covering to be airtight. Do not attach covering rigidly to duct work.

3.2 Manufacturer’s field services

.1 Prepare and start systems.

.2 Inspect installation periodically.

.3 Provide services of AABC testing agency to take noise measurement. Use meters meeting requirements of ASA 47 (ANSI S1.4).

.4 After start-up, final corrections and balancing of systems take octave band sound measurements over full audio frequency range in areas adjacent to mechanical equipment rooms, duct and pipe shafts, and other critical locations, as directed.

.5 Provide one-third octave band measurements of artificial sound sources in areas indicated as having critical requirements.

.6 Submit complete report of test results including sound curves.

End of section

1 General

1.1 Section includes

.1 Ceiling centrifugal fans.

.2 Air Curtains.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 AMCA 99 - Standards Handbook.

.2 AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

.3 AMCA 261 - Directory of Products Licensed to Bear the AMCA Certified Ratings Seal.

.4 AMCA 300 - Reverberant Room Method for Sound Testing of Fans.

.5 AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

.6 UL 705 - Power Ventilators.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Provide shop drawings and product data on fans and accessories including fan curves with specified operating point clearly plotted, sound power levels at rated capacity, and electrical characteristics and connection requirements.

.4 Manufacturer's Installation Instructions.

1.5 Extra material

.1 Provide two (2) sets of belts for each fan.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Air Curtains

.1 Manufacturers: Mars indicated or equivalent products by;

.1 Biddle;

.2 Schwank; or

.3 Approved alternate subject to shop drawing review.

.2 Performance: as scheduled on drawings

.3 Motor: Totally enclosed air over (TEAO) motor with sealed lifetime pre-lubricated ball bearings. Meets NEC.CSA Listed.

.4 Fans: Forward curved centrifugal type, double width, and double inlet design, directly driven to an electric motor.

.1 Provide rigid mounted base between motor and frame.

.2 Factory balanced blower wheel assembly statically and dynamically.

.5 Housing: Self-contained one-piece type with sufficient strength for mounting from pre-punched mounting holes at both ends to adjacent walls or ceiling without intermediate support.

.1 Provide 12 gauge electro or hot dipped galvanized steel sheet housing conforming to ASTM A 591 and/or ASTM A 653.

.2 Air Inlet Grille and/or Filters: Provide air inlet grille and/or filters specified.

.3 Discharge: Provide integral discharge nozzle specified.

.4 Finish and Color: Provide with, no VOC, corrosion resistant polyurethane powder coated finish for sheet metal housings. Colour to be selected at shop drawing review.

.6 Discharge Nozzle: Adjustable air foil vanes with a plus/minus 40-degree sweep front to back.

.1 Air Velocity at Nozzle: 147 Inch (3736 mm) Wide Units: 3009 feet/min (15.3 m/s) three 3HP motor/fan assemblies.

.2 Air Speed at Floor: Minimum of 400 fpm (2 m/s) at 3 feet (914 mm) from the floor.

.3 Sound Pressure Level At 10 feet (3 m) From Nozzle: 66 dBA

.7 Motor Control Panels for Unheated Units: Factory mounted.

.8 Door-Activated Limit switch(s): Provide, field installed 250-Volts, 20 amps NEMA 4X limit switch to control air curtain(s) as follows; Automatic on/off control, activates air curtain when door is opened and turns off when door is closed. Provide a separate control panel for three-phase motors and/or units exceeding 1 HP, 250-Volts or 20 amps controlled by a limit switch.

.9 Provide mounting hardware as required for the opening.

.10 Electrical Characteristics and Components

.1 Electrical Characteristics: as scheduled

.2 Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code.

.3 Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.

2.3 Ceiling centrifugal fans

.1 Manufacturers: Greenheck indicated or equivalent products by:

.1 PennBarry;

.2 Loren Cook;

.3 Carnes;

.4 Broan;

.5 Reversomatic; or

.6 Approved alternate subject to shop drawing review.

.2 Product Requirements:

.1 Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

.2 Sound Ratings: AMCA 301, tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.

.3 Fabrication: Conform to AMCA 99.

.3 Performance: as scheduled on drawings

.4 Fan Unit: Direct driven, with spun acoustically insulated galvanized steel housing; resilient mounted motor; high impact polystyrene grille ; vibration isolation hangers, flexible inlet and/or outlet connections, non-chatter back draft damper and either a roof or wall termination as indicated.

.5 UL/cUL Classified ceiling radiation damper (fire flap) rated for three (3) hours of fire resistance.

.6 Electrical Characteristics and Components

.1 Electrical Characteristics: as scheduled

.2 Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to code.

.3 Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.

3 Execution

3.1 Installation

.1 Install fans and air curtains in accordance with manufacturer's instructions.

.2 Provide flexible duct connections between each fan and ductwork. Ensure metal bands of connectors are parallel with minimum 1 in. (25 mm) flex between ductwork and fan while running.

.3 Provide sheaves as required for final air balance.

.4 Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

.5 Cabinet & Ceiling Exhaust fans;

.1 Support exhaust fans independently of ductwork.

.6 Air Curtains;

.1 Install air curtains plumb, level, square, true to line, and weathertight, without warp or rack.

.2 Anchor air curtains securely in place to supports.

.3 Coordinate with sheet metal flashing as specified in Section 07 62 00 – Prefinished Metal Flashing and Trim.

.4 Install joint sealants as specified in Section 07 92 00 – Sealants.

.5 Coordinate with electrical power as specified in Section 26 05 00 – General Electrical Requirements.

.6 Install door limit switches and adjust for correct operation.

.7 Adjust air foil vanes located within the discharge nozzle as required for prevailing conditions at each opening.

End of section

1 General

1.1 Section includes

.1 De-stratification (HVLS) fans.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 AMCA 99 - Standards Handbook.

.2 AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

.3 AMCA 261 - Directory of Products Licensed to Bear the AMCA Certified Ratings Seal.

.4 AMCA 300 - Reverberant Room Method for Sound Testing of Fans.

.5 AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

.6 UL 705 - Power Ventilators.

.7 National Fire Protection Association (NFPA)

.8 Canadian Standards Association (CSA)

.9 National Electrical Manufacturers Association (NEMA)

.10 National Electrical Code (NEC)

.11 Occupational Safety and Health Administration (OSHA)

.12 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

.13 Air Movement and Control Association (AMCA)

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Provide shop drawings and product data on fans and accessories including fan curves with specified operating point clearly plotted, sound power levels at rated capacity, and electrical characteristics and connection requirements.

.4 Mounting Shop Drawings: Provide shop drawings sealed by a Professional Engineer licence in Ontario of complete mounting assembly. Include connection to structural steel elements, and design of additional supporting steel required for manufacturers mounting assembly to support all loads associated with HVLS fans.

.5 Manufacturer's Installation Instructions

.6 Ceiling fan sizing, placement, and performance shall be verified using computational fluid dynamics (CFD) analysis. At a minimum, the input data for the CFD analysis shall include the ceiling fan(s), significant obstructions to airflow at the floor level, and the actual space dimensions. As verification of performance, the submittal shall include results of the CFD analysis including, at a minimum, the following performance metrics determined in accordance with ANSI/ASHRAE Standard 55-2017: average air speed, minimum, maximum, and average cooling effect from elevated air speed, Predicted Mean Vote, and Predicted Percentage Dissatisfied for seated and standing occupants in each occupied zone.

1.5 Quality assurance

.1 Certifications.

.1 The fan assembly, as a system, shall be Intertek/ETL-certified and built pursuant to the guidelines set forth by UL standard 507 and CSA standard 22.2 No. 113.

.2 The fan shall be compliant with NFPA 13 - Standard for the Installation of Sprinkler Systems, NFPA 72 - National Fire Alarm and Signaling Code, and NFPA 70 - National Electrical Code (NEC).

.3 Controllers shall comply with National Electrical Code (NEC) and Underwriters Laboratory (UL) standards and shall be labeled where required by code.

.2 Manufacturer Qualifications

.1 The fan and any accessories shall be supplied by Big Ass Fans, which has a minimum of fifteen (15) years of product experience, or approved alternate.

.2 ISO 9001 compliant

.3 The manufacturer shall not be listed on the Air Movement and Control Association International Inc. (AMCA) Certified Ratings Program (CRP) Non-Licensed Products report in the previous thirty six (36) months.

1.6 Delivery, storage, and handling

.1 Deliver product in original, undamaged packaging with identification labels intact. The fan shall be new, free from defects, and factory tested.

.2 The fan and its components must be stored in a safe, dry location until installation.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 High volume low speed / de-stratification (HVLS) fans

.1 Manufacturer: Big Ass Fans Company indicated as base design, or equivalent products by:

.1 Greenheck;

.2 Banvil; or

.3 Approved alternate subject to shop drawing review.

.2 Complete Unit

.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 digital wall 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 Sustainability Characteristics:

.1 The fan shall be designed to move an effective amount of air for cooling and destratification in a variety of applications (including industrial, commercial, and agricultural) over an extended life. The fan components shall be designed specifically for high volume, low speed fans to ensure lower operational noise.

.2 The digital wall controller shall be designed to control Big Ass Fans or other approved alternate from a secure, centralized location, and shall be designed specifically for high volume, low speed Big Ass Fans or approved alternate to ensure maximum control.

.3 Good workmanship shall be evident in all aspects of construction. Field balancing of the airfoils shall not be necessary

.3 Variable Frequency Drive (VFD)

.1 The onboard VFD shall be pre-wired to the motor and factory-programmed to minimize starting and braking torques for smooth and efficient operation.

.2 The VFD shall be pre-wired 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).

.3 The VFD shall include a quick disconnect feature to allow for easy replacement of the drive.

.4 A 15 ft. (4.6 m) incoming power cord shall be pre-wired to the VFD.

.5 The VFD shall be housed in a sealed, IP66-rated aluminum enclosure for protection in harsh environments.

.6 The VFD shall have an operating temperature of up to 131 ˚F (55 ˚C) ambient conditions.

.7 The VFD and digital wall controller shall communicate over a wired connection using Modbus communication protocol.

.8 The VFD shall be capable of integration with building automation systems.

.9 The VFD shall be equipped with the most current firmware version, and the VFD firmware shall be subject to updates without notice.

.10 The VFD shall include an embedded accelerometer with precise rotor control sensing to instantly detect impacts and obstructions and automatically shut down the fan

.4 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.

.5 Motor

.1 The fan motor shall be a permanent magnet brushless motor rated for continuous operation at maximum speed with the capability of modulating the fan speed from 0–100 % without the use of a gearbox or other mechanical means of control. No other motor shall be accepted.

.2 The motor shall be totally enclosed and rated IP66.

.3 The motor frame shall be designed for ease of service.

.4 The motor shall be manufactured with a double baked Class F insulation and shall be capable of continuous operation in -4 ˚F to 131 ˚F (-20 ˚C to 55 ˚C) ambient conditions.

.5 The motor shall operate from any voltage ranging from 200–277 VAC, single or three-phase, 50/60 Hz or 380–480 VAC, three-phase, 50/60 Hz without requiring adapters or customer selection.

.6 Airfoil system

.1 The fan shall be equipped with six (6) Powerfoil 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. All airfoil hardware shall be SAE Grade 8 or equivalent.

.2 The fan shall be equipped with six (6) Powerfoil winglets on the ends of the airfoils. The winglets shall be molded of a polypropylene blend. The standard color of the winglets shall be “Safety Yellow.”

.3 Airfoil Restraint System

.1 All 20 to 24 ft. (6 to 7.3 m) diameter fans shall be equipped with a patented airfoil restraint system to provide redundant safety between the ends of the airfoils and the fan hub. The airfoil restraint system shall be available as an option on smaller diameter fans.

.2 The airfoil restraint system shall be comprised of durable, lightweight nylon safety straps that shall extend from winglets through the airfoils and secure to the fan hub with 12 gauge stamped steel safety clips.

.3 The straps shall be made of 1 in. (24 mm) wide heavy-duty nylon webbing rated for 825 lb (374 kg). The loops at the ends of the straps shall be secured in a double-stitch pattern for reinforced durability.

.4 The straps shall be precisely matched to each fan’s diameter, eliminating the need for a tensioning mechanism and reducing the opportunity for noise.

.5 The straps shall run along the inside of the airfoils for an uninterrupted look.

.6 Safety clips shall be pre-attached to each winglet at the factory to comprise the outer anchor points and provide tension, while clips on the opposite end shall secure to threaded inserts incorporated in the fan hub

.7 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.

.8 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 to allow for adjustments to be made after installation on the mounting structure to ensure the fan will hang plumb.

.2 The upper mount shall be of ASTM A-36 steel, welded construction, at least 3/16 in. thick, and powder coated for appearance and corrosion resistance. No mounting hardware or parts substitutions, including cast aluminum, are acceptable.

.3 All mounting bolts shall be SAE Grade 8 or equivalent

.9 Hub

.1 The fan hub shall be 19 in. (480 mm) 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, six (6) aluminum spars, and one (1) aluminum spacer. 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 motor by means of one (1) aerospace grade lug nut. The hub shall incorporate three (3) safety retaining clips made of ¼ in. (6 mm) thick steel that shall restrain the hub/airfoil assembly

.10 Safety cables

.1 The fan shall be equipped with an upper safety cable that provides an additional means for securing the fan assembly to the building structure. The upper safety cable shall have a diameter of ⅜ in. (10 mm).

.2 The fan shall be equipped with two lower safety cables pre-attached to the motor that shall provide an additional means of securing the fan to the extension tube. The lower safety cables shall have a diameter of ⅜ in. (10 mm).

.3 The safety cables shall be fabricated out of 7 x 19 galvanized steel cable. The end loops shall be secured with swaged Nicopress® or approved alternate sleeves, pre-loaded and tested to 3,200 lbf (13,345 N).

.4 Field construction of safety cables is not permitted.

.11 Digital Variable Speed Wall Controller

.1 The fan shall be equipped with a digital variable speed wall controller. The controller user interface shall be a wall-mounted, touch interface.

.2 The 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 controller to the fan's VFD and to provide power to the controller.

.4 The controller mounting location shall meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.

.12 The controller shall have an IP65 rating.

.1 The controller shall provide fan start/stop, speed, and direction control functions.

.2 The controller shall provide diagnostic and fault history information for the connected fan, as well as the ability to configure fan parameters with the assistance of Big Ass Fans Customer Service or approved alternate manufacturer's customer service.

.3 The controller interface shall be able to be secured with a passcode to prevent unauthorized access to fan controls and settings.

.4 The controller shall operate out of the box without setup and upon connection to CAT5 cable.

.13 BAFCon Controller

.1 The fan shall have the option of operating with the BAFCon controller.

.2 The digital controller user interface shall be a wall-mounted touchscreen with a 5 in. (127 mm) display and an 800 (RGB) x 480 pixel resolution.

.3 The digital controller shall be mounted to a standard rectangular or square outlet box.

.4 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 BAFCon and the VFD. The cable shall provide power to the digital controller.

.5 The digital controller shall not require a 120 V power supply at the controller mounting location.

.6 The digital controller mounting location shall meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.

.7 The digital controller shall support up to eight Powerfoil D fans controlled as a group or individually.

.8 The digital controller shall provide fan start/stop, speed, and direction control functions.

.9 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 Big Ass Fans Customer Service or approved alternate manufacturer's customer service.

.10 The digital controller shall include optional SmartSense functionality to maximize energy savings. SmartSense shall provide the capability to automatically control the speed of Big Ass Fans or approved alternate using information from user-determined settings and built-in temperature and humidity sensors.

.11 The digital controller interface shall be able to be secured with user and admin passcodes to prevent unauthorized access to fan controls and settings.

.12 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.

.13 BAFCon Multi-Fan Accessory Kit

.1 If multiple fans will be installed, the BAFCon Multi-Fan Accessory Kit or approved alternate shall be included.

.2 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

.14 Guy Wires

.1 Included for installations with extension tubes 4 ft. (1.2 m) or longer to limit the potential for lateral movement.

3 Execution

3.1 Installation

.1 Install fans in accordance with manufacturer's instructions, and reviewed shop drawings.

.2 Preparation

.1 Fan location shall have a typical bar joist or existing I-beam structure from which to mount the fan.

.2 Mounting structure shall be able to support weight and operational torque of fan. Install mounting support as indicated in Mounting Shop Drawings prepared by a Professional Engineer Licence in Ontario.

.3 Fan location shall be free from obstacles such as lights, cables, or other building components.

.4 Check fan location for proper electrical requirements. Consult installation guide for appropriate circuit requirements.

.5 Each fan requires dedicated branch circuit protection.

.6 The fan system and the fan controller shall be installed according to the instructions in the fan installation guide.

.7 Install a rectangular or square outlet box at the wall controller mounting location.

.8 For multi-fan installations with the BAFCon controller, ensure the appropriate accessory kit is included as described above. The kit shall be installed by a factory-certified installer according to the instructions included with the kit.

.3 Installation

.1 The fan and wall controller shall be installed by a factory-certified installer according to the manufacturer's installation guide, which includes acceptable structural dimensions and proper sizing and placement of angle irons for bar joist applications. Provide professional Engineer's certification, in the form of a stamped print or letter verifying mounting assembly is in accordance with reviewed shop drawings, submitted prior to installation.

.2 Minimum Distances

.1 Airfoils shall be at least 10 ft. (3 m) above the floor.

.2 Installation area shall be free of obstructions such as lights, cables, sprinklers, or other building structures with the airfoils at least 2 ft. (610 mm) clear of all obstructions.

.3 The fan shall not be located where it will be continuously subjected to wind gusts or in close proximity to the outputs of HVAC systems or radiant heaters. Additional details are in the fan installation guide.

.3 In buildings equipped with sprinklers, including ESFR sprinklers, fan installation shall comply with all of the following:

.1 The maximum fan diameter shall be 24 ft. (7.3 m).

.2 The HVLS fan shall be centered approximately between four adjacent sprinklers.

.3 The vertical clearance from the HVLS fan to the sprinkler deflector shall be a minimum of 3 ft. (0.9 m).

.4 All HVLS fans shall be interlocked to shut down immediately upon receiving a waterflow signal from the alarm system in accordance with the requirements of NFPA 72 - National Fire Alarm and Signaling Code.

.5 Mount the wall controller to a flat, readily accessible surface that is free from vibration and away from foreign objects and moving

equipment. The controller mounting location must meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.

.6 If the SmartSense feature will be used, the BAFCon 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 fan(s) it will control. Additional mounting guidelines can be found in the controller installation guide.

End of section

1 General

1.1 Section includes

.1 Single duct variable volume units.

.2 Integral sound attenuator.

.3 Integral damper motor operators.

.4 Integral controls.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 ADC 1062 - Air Distribution and Control Device Test Code.

.2 NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

.3 UL 181 - Factory-Made Air Ducts and Connectors.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.

.4 Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalogue performance ratings which indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.

.5 Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 250 to 1,000 Pa.

.6 Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.

1.5 Quality assurance

.1 Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 Warranty

.1 Provide five (5) year warranty starting from date of Substantial Performance.

.2 Warranty: Include coverage of system powered control systems.

1.8 Delivery, storage and protection

.1 Provide two (2) additional electric motors of each size.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Single duct terminal units

.1 Manufacturers:

.1 Krueger products indicated.

.2 Other acceptable manufacturers offering equivalent products.

.1 E. H. Price;

.2 Titus;

.3 Metalaire; or

.4 Approved alternate.

.2 Basic Assembly:

.1 Casings: Minimum 20ga. (0.813mm) galvanized steel with access panel.

.2 Lining: 1 in (25mm) thick dual density fiberglass insulation, 24g/L density, meeting NFPA 90A requirements and UL 181 erosion requirements.

.3 Plenum Air Inlets: Round 20ga. (0.813mm) stub connections for duct attachment.

.4 Plenum Air Outlets: A slip and drive connections.

.3 Basic Unit:

.1 Configuration: Air volume damper assembly inside unit casing. Locate control component inside protective metal shroud.

.2 Volume Damper: Construct of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 2% of design air flow at 0.25kPa inlet static pressure.

.3 Mount damper operator to position damper normally open.

.4 Attenuator Section: continuous extension of the standard galvanized coated steel casing.

.5 Round Outlet: Discharge collar matching inlet size.

.6 Damper Operator: electronic

.7 Airflow sensor: A linear, multi-point, velocity averaging sensor with an amplified signal.

.8 Thermostat: Electronic type with appropriate mounting hardware.

3 Execution

3.1 Installation

.1 Install to manufacturer's instructions.

.2 Provide ceiling access doors or locate units above easily removable ceiling components.

.3 Support units individually from structure. Do not support from adjacent ductwork.

.4 Connect to ductwork

.5 Verify that electric power is available and of the correct characteristics.

3.2 Adjusting

.1 Adjust work as required to meet the design intent.

.2 Reset terminal box volume with damper operator attached to assembly allowing flow range modulation from 100 % of design flow to 0 % full flow.

End of section

1 General

1.1 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

.3 Section 23 31 00 – Ductwork

.4 Section 23 33 00 – Ductwork Accessories

1.2 References

.1 Air Movement and Control Association (AMCA):

.1 AMCA Publication 511, Product Rating Manual for Air Control Devices.

.2 Air Conditioning, Heating, and Refrigeration Institute (AHRI):

.1 ANSI/AHRI 885, Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

.3 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):

.1 ANSI/ASHRAE 36B-63, Method of Testing for Rating the Acoustic Performance of Air Control and Terminal Devices.

.2 ASHRAE Standard 70, Method of Testing for Rating the Performance of Air Outlets and Inlets.

.4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

.1 SMACNA, HVAC Duct Construction Standards - Metal and Flexible.

.5 Ontario Building Code (OBC)

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Shop Drawings:

.1 Provide submittals in accordance with Section 01 33 00 – Submittal Procedures.

.2 Submit product literature for all equipment in this Section.

.4 Colour Chart(s): Submit manufacturer's colour chart(s) for all items for which a finish colour is to be selected.

1.4 Delivery, storage and handling

.1

.2 Deliver materials to site in original factory packaging, labelled with the Manufacturer's name and address.

.3 Store at temperatures and conditions recommended by the Manufacturer.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Grilles, registers, and diffusers for inlets to exhaust and return air system and as outlet for supply air systems shall be sized shown on the Contract Drawings.

.2 Refer to the Grilles and Diffusers Schedule on drawings.

.3 Where special colour finish or material is noted submit samples for the Consultant selection. Refer to the Contract Drawings for model and capacity.

.4 Select all diffusers to provide uniform air coverage without overlap. Air velocity up to a height of 1,800 mm (6 ft.) above the floor shall be 0.127 to 0.254 m/s (25 to 50 fpm).

.5 Noise generated by diffusers shall be such that room sound pressure level does not exceed NC 32 with an 8db room attenuation, the sound power level reference to 10 to –12 power watts.

.6 Diffusers shall meet test requirements of ASHRAE Standard 36B-63, including air pattern and noise levels for air quantities from 10% to 110% of the required maximum air flow. Sound power tests shall be measured in accordance with ASHRAE Standards 36B-63.

.7 In gypsum board or plaster ceiling applications, provide matching mounting frame. Colour to match ceiling.

.8 In T-bar ceilings, manufacturer shall coordinate diffuser compatibility with T-bar ceiling specified by the architectural division. Colour shall match colour of ceiling tile in lay-in ceilings. Diffusers to suit ceiling grid as required imperial or metric.

.9 Acceptable manufacturers are:

.1 E.H. Price Ltd.;

.2 Nailor Industries Inc.;

.3 Titus HVAC;

.4 Krueger;

.5 Metalaire; or

.6 Approved alternate.

3 Execution

3.1 Installation of diffusers, registers, and grilles

.1 Provide grilles and diffusers where shown on the Drawings. Refer to the architectural drawings for actual locations of diffusers, grilles and registers and install to suit. The mechanical drawings show intent and number of diffusers, grilles and registers required.

.2 Wherever possible, diffusers, registers, and grilles shall be the product of one manufacturer. Unless otherwise specified connect diffusers, registers, and grilles in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible.

.3 Provide sheet metal plenums, constructed of the same material as the connecting duct, for linear grilles and/or diffusers where shown on the Contract Drawings. Construct and install the 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 the duct connection collar(s) with volume control device(s).

.4 Install in accordance with manufacturer's instructions. Fit frame with gasket to prevent leakage and smudging. Install with flat head cadmium plated screws in countersunk holes where fastenings are visible.

.5 For exposed ductwork installations, all connections to grilles shall be oversized and shall have in-turned flanges to meet the flange of the grilles and the duct. Out-turned or exposed flanges with screw mounting shall not be accepted.

.6 For transfer air applications where air is transferred though a ceiling, partition or door provide grilles in all finished spaces. Provide transfer grille on both sides of the finished areas.

.7 Install mounting frame tied into plaster and gypsum board ceilings to allow lay in type diffusers to rest on the frame.

.8 Contractor shall caulk around edges of linear diffusers in installations with imperfect walls.

.9 Paint ductwork visible behind air outlets matte black.

.10 Confirm diffuser, register, and grille finishes prior to ordering.

.11 Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

.12 Install diffusers to duct work with airtight connection.

.13 Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

End of section

1 General

1.1 Section includes

.1 Cleaning of pipe and fittings.

.2 Cleaning of equipment.

.3 Supply, installation testing and adjusting of chemical feed equipment.

.4 Chemical treatments of piping systems, boilers and cooling towers.

.5 Supply of chemicals.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.

.4 Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.

.5 Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.

.6 Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.

1.4 Quality assurance

.1 Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three (3) years documented experience. Company to have local representatives with water analysis laboratories and full time service personnel.

.2 Installer: Company specializing in performing the work of this section with minimum three years documented experience and approved by manufacturer.

1.5 Regulatory requirements

.1 Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and for to public sewage systems.

.2 Products Requiring Electrical Connection: Listed and classified by CSA as suitable for the purpose specified and indicated.

1.6 Maintenance materials

.1 Provide sufficient chemicals for treatment and testing during warranty period.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Manufacturers

.1 GE Water Tech (Dearborn);

.2 Buckman Laboratories;

.3 Bird Archer;

.4 Ashland Drew; or

.5 Approved alternate.

2.3 Materials

.1 System Cleaner:

.1 Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and sodium molybdate.

.2 Biocide; chlorine release agents such as sodium hypochlorite or calcium hypochlorite, or microbiocides such as quarternary ammonia compounds, tributyl tin oxide, methylene bis (thiocyanate), or isothiazolones.

.2 Closed System Treatment (Water):

.1 Sequestering agent to reduce deposits and adjust pH; polyphosphate. .

.2 Corrosion inhibitors; liquid boron-nitrite, sodium nitrite and borax, sodium totyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.

.3 Conductivity enhancers; phosphates or phosphonates.

2.4 Bypass pot feeder

.1 2 gal. (6.8 L) quick opening cap for working pressure of 175 psi (1,200 kPa).

2.5 Solution metering pump

.1 Positive displacement, diaphragm pump with adjustable flow rate, thermoplastic construction, continuous-duty fully enclosed electric motor and drive, and built-in relief valve.

.2 Electrical Characteristics:

.1 120 volts, single phase, 60 Hz.

.2 Cord and Plug: Provide unit with 6 ft. (2 m) cord and plug for connection to electric wiring system including grounding connector

2.6 Solution tanks

.1 30 gal. (114 L) capacity, polyethylene, self-supporting, 1 gal. (3.8 L) graduated markings; moulded fibreglass cover with recess for mounting pump, agitator, and liquid level switch.

2.7 Agitator

.1 Totally enclosed electric motor, cast iron clamp and motor mount, ½ in. (13 mm) diameter coated Type 316 stainless steel propeller.

.2 Electrical Characteristics:

.1 120 volts, single phase, 60 Hz.

.2 Cord and Plug: Provide unit with 6 ft. (2 m) cord and plug for connection to electric wiring system including grounding connector.

2.8 Test equipment

.1 Provide white enamel test cabinet with local and fluorescent light, capable of accommodating 4 – 10 ml zeroing titrating burettes and associated reagents.

.2 Provide the following test kits:

.1 Alkalinity titration test kit.

.2 Chloride titration test kit.

.3 Sulphite titration test kit.

.4 Total hardness titration test kit.

.5 Low phosphate test kit.

.6 Conductivity bridge, range 0 - 10,000 micro ohms.

.7 Creosol red pH slide complete with reagent.

.8 Portable electronic conductivity meter.

.9 High nitrite test kit.

3 Execution

3.1 Preparation

.1 Systems to be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

.2 Place terminal control valves in open position during cleaning.

.3 Verify that electric power is available and of the correct characteristics.

3.2 Cleaning sequence

.1 Concentration:

.1 As recommended by manufacturer.

.2 1 kg per 1,000 L of water contained in the system.

.3 1 kg per 1,000 L of water for hot systems and 1 kg per 500 L of water for cold systems.

.4 Fill steam boilers only with cleaner and water.

.2 Hot Water Heating Systems:

.1 Apply heat while circulating, slowly raising temperature to 160 °F (71 °C) and maintain for twelve (12) hours minimum.

.2 Remove heat and circulate to 100 °F (37.8 °C) or less; drain systems as quickly as possible and refill with clean water.

.3 Circulate for six (6) hours at design temperatures, then drain.

.4 Refill with clean water and repeat until system cleaner is removed.

.3 Chilled Water Systems:

.1 Circulate for forty eight (48) hours, then drain systems as quickly as possible.

.2 Refill with clean water, circulate for twenty four (24) hours, then drain.

.3 Refill with clean water and repeat until system cleaner is removed.

.4 Use neutralizer agents on recommendation of system cleaner supplier and approval of Consultant.

.5 Flush open systems and glycol filled closed systems with clean water for one hour minimum. Drain completely and refill.

.6 Remove, clean, and replace strainer screens.

.7 Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.3 Installation

.1 Install to manufacturer's instructions.

3.4 Closed system treatment

.1 Provide one (1) bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.

.2 Introduce closed system treatment through bypass feeder when required or indicated by test.

.3 Provide ¾ in. (19 mm) water coupon rack around circulating pumps with space for four (4) test specimens.

End of section

1 General

1.1 Section includes

.1 Electric Boilers.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 ASME SEC 4 - Boiler and Pressure Vessel Codes - Rules for Construction of Heating Boilers.

.2 ASME SEC 8D - Boilers and Pressure Vessel Codes - Rules for Construction of Pressure Vessels.

.3 CSA B51-03, Boiler, Pressure Vessel, and Pressure Piping Code.

.4 HI (Hydronics Institute) - Testing and Rating Standard for Cast Iron and Steel Heating Boilers.

.5 NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit shop drawings for each major piece of equipment.

.4 Shop drawings shall include;

.1 Dimension drawings of water heaters indicating components and connections to other equipment and piping.

.2 Electrical characteristics and connection requirements.

.3 Performance data.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

.2 Provide equipment with the manufacturer's name, model number, and rating/capacity identified.

.3 Ensure products and installation of specified products are to recommendations and requirements of the following organizations:

.1 National Sanitation Foundation (NSF).

.2 American Society of Mechanical Engineers (ASME).

.3 National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).

.4 National Electrical Manufacturers' Association (NEMA).

.5 Underwriters Laboratories (UL).

1.6 Regulatory requirements

.1 Conform to applicable code for internal wiring of factory wired equipment.

.2 Conform to ASME SEC 4 and SEC 8D for boiler construction.

.3 Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 Delivery, storage and protection

.1 Transport, handle, store, and protect products.

.2 Protect units before, during, and after installation from damage to casing by leaving factory shipping packaging in place until immediately prior to final acceptance.

1.8 Warranty

.1 Provide five (5) year manufacturer warranty on boiler vessel starting from date of Substantial Performance, and 18 months manufacturer warranty on boiler parts.

2 Products

2.1 Manufacturers

.1 Precision Boilers model indicated or approved alternate.

.2 Other acceptable manufacturers offering equivalent products, subject to shop drawing review:

.1 Cleaver Brooks, WB series;

.2 Laars, EB series; or

.3 Other approved alternate.

.3 Refer to schedule on drawings.

2.2 General

.1 The vessel shall be ASME "H" stamped and National Board registered with a maximum working pressure of 30 psi. The unit(s) shall be fully tested using standard UL834, shall bear the CSA mark, and shall meet the requirements of ASME CSD.

.2 The boiler shall be available in 600V three phase voltage, and shall include a dedicated 15A 120V single phase control circuit (general service) that includes a primary pump relay. Terminals shall be provided on the boiler for connection to an emergency stop switch. Wiring within the main cabinet shall be rated at 75°C or higher.

.3 The boiler shall have a built-in digital temperature control with display. The control shall include supply and return water temperature sensing. 0-10VDC connections shall be standard, to allow for external boiler control. Gateways for BACnet protocol shall be available from the boiler manufacturer.

.4 Automatic electronic temperature control shall be electronic multi-stage step controller.

.5 The boiler shall include a mounted low water cutoff with manual reset, a manual reset temperature high limit set at 220°F, an automatic reset high temperature limit set at 210°F, and a temperature and pressure gauge.

.6 The heating elements shall be constructed using incoloy sheathing for long service life. The boiler shall have a circuit breaker for each element, providing convenient and safe disconnection of individual elements.

.7 The vessel shall be wrapped with 4 in thick blanket of fiberglass insulation and be fully enclosed in a minimum 14-gauge cabinet. Both base and cabinet shall be painted with powder coat enamel.

.8 An integral electric control panel with key-locked door enclosure shall be included. The control enclosure shall contain all boiler controls and adjustments. The boiler operator shall not be required to enter main cabinet for resets or other functions.

.9 Provide following features and options:

- .1 Main supply circuit lugs with integral branch circuit fusing
- .2 120 volt fused control transformer
- .3 Magnetic contactors rated 500,000 cycles
- .4 125 Amp non-fused disconnect switch
- .5 Ground Fault Detection System
- .6 Watt-hour meter
- .7 Safety door interlock
- .8 Remote reset of setpoint (to accommodate BAS Analog reset signal)
- .9 Local/Remote switch to accommodate BAS Analog control signal
- .10 Flow switch
- .11 High/low pressure switch / Alarms
- .12 Full port drain valve
- .13 On/Off power switch with pilot light
- .14 Pressure gauge with cock
- .15 ASME safety relief valve
- .16 One status pilot light for each step
- .17 Low Water Cut-Off Switch: Probe type with manual reset, test & pilot light
- .18 KW limiting switch: On/Off toggle switch for each step
- .19 High temperature limit switches: one with an auto reset and one with a manual reset

.20 Temperature gauge: a dial type temperature gauge plus a digital electronic temperature readout on the temperature controller interface

3 Execution

3.1 Installation

.1 Install to manufacturer's instructions.

.2 Install boiler on a concrete housekeeping base, sized minimum 100 mm larger than boiler base.

.3 Provide piping connections and accessories as indicated.

.4 Pipe relief valves to nearest floor drain.

.5 Install circulator and diaphragm expansion tank on boiler.

.6 Provide for connection to electrical service.

End of section

1 General

1.1 Section includes

.1 Direct geo-exchange ground heat exchanger system.

1.2 Related requirements

.1 Section 20 05 00 – Common Mechanical Work Results

1.3 References

.1 Acronyms

.1 AMERICAN SOCIETY OF HEATING, REFRIGERATING & AIR-CONDITIONING ENGINEERS (ASHRAE)

.2 ASTM INTERNATIONAL (ASTM)

.3 CANADIAN STANDARDS ASSOCIATION (CSA)

.4 INTERNATIONAL GROUND SOURCE HEAT PUMP ASSOCIATION (IGSHPA)

.5 UNDERWRITERS LABORATORIES OF CANADA (cUL)

.2 Reference Standards:

.1	ASHRAE	Commercial/Institutional Ground Source Heat Pump Engineering Manual
.2	ASHRAE	Ground-Source Heat Pumps-Design of Geothermal Systems for Commercial and Institutional Buildings
.3	ASHRAE, 1998	Operating Experiences with Commercial Ground Source Heat Pump System
.4	ASTM D-1693	Environmental Stress-Cracking of Ethylene Plastics
.5	ASTM D-2513	Polyethylene Pressure Pipe, Tubing, and Fittings
.6	ASTM D-2657	Heat Fusion Joining Polyolefin Pipe and Fittings
.7	ASTM D-2683	Socket Fusion Fittings
.8	ASTM D-2837	Hydrostatic or Pressure Design Basis for Thermoplastic Pipe Products

.9	ASTM D-3035	Polyethylene (PE) Plastic Pipe
.10	ASTM D-3261	Butt/Saddle Fusion Fittings
.11	ASTM D-3350	Polyethylene Plastics Pipe and Fittings Materials
.12	ASTM D-5084	Measurement of Hydraulic Conductivity
.13	ASTM D-5334	Determination of Thermal Conductivity of Soils and Soft Rock
.14	ASTM E202	Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols
.15	ASTM F-1055	Electro-fusion Fittings
.16	ASTM F-1290	Electrofusion Joining Polyolefin Pipe and Fittings
.17	ASTM F-2164	Field Testing of Polyethylene (PE) Pressure Piping Systems
.18	ANSI/NSF Standard 60	Drinking Water Treatment Chemicals Health
.19	CSA C448-13	Design and Installation of Earth Energy Systems
.20	IGSHPA 21025	Ground Source Heat Pump Residential and Light Commercial Design and Installation Guide
.21	IGSHPA 21035	Design and Installation Standards
.22	ULC-S102-10	Surface Burning Characteristics of Building Materials

.3 Definitions

.1 The following definitions apply to this Section and the Drawings that are referenced herein or that otherwise relate to the work of this Section:

.1 GHX: Refers to ground heat exchanger, and may include vertical, horizontal trenching, horizontal boring, slinky, pond or lake heat exchanger buried in the ground or submerged in a body of water.

.2 GHX circuits: HDPE pipe buried in the ground in a horizontal orientation designed to transfer energy to and from the

ground. Typically, a number of GHX circuits are fusion welded to a GHX header that is in turn fusion welded to supply and return pipes. Heat transfer fluid is circulated through the assembly to a building.

.3 U-tube: An assembly of two lengths of HDPE pipe connected on one end with a manufactured, purpose built U-bend.

.4 GHX header: Connection points between supply and return runout piping and GHX circuits. GHX headers are generally buried in the ground adjacent to the GHX field and are comprised of an assembly of fusion welded fittings and pipe. Fittings and pipe are manufactured using HDPE resin and are connected using specified heat fusion method.

.5 Runout piping: Supply and return runout piping refers to the HDPE piping installed to connect the GHX circuit piping to the GHX manifold.

.6 GHX manifold: Connection point for supply and return runout piping from GHX field. A GHX manifold is typically located inside a building or in geothermal vault located away from the building.

.7 GHX module: Completed assembly of GHX components, including GHX manifold, supply and return runout piping, GHX header and GHX circuits.

.8 GHX field: Assembly of all GHX modules connected to a single building or system.

.9 HDPE: High Density Polyethylene material used for pipes and fittings.

.10 SDR: Standard Dimension Ratio for HDPE pipe sizes.

.11 Net Borehole Length: Actual length of installed and active pipe in borehole after tie-in. This depth must match specification on Drawings.

1.4 Description

.1 The work described in this Section is intended to relay the required scope of the design and installation of the Direct Geo-Exchange Ground Heat Exchanger system. The work covered under this Section of the

Specifications is intended to include the furnishing of all equipment, materials and labour reasonably incidental to the complete operating installation of the horizontal closed-loop ground heat exchanger (GHX). This generally includes the drilling of the horizontal boreholes, installation of the circuit pipe, installation of horizontal supply and return runout connections to the supply and return manifolds, excavation and backfill of trenches and pressure testing. The work also includes flushing and purging of the GHX piping, charging the system with the glycol fluid mixture, and fluid balancing for all circuits.

.2 The extent of ground heat exchanger work is indicated on the Drawings and by requirements of this Section:

.1 The closed-loop ground heat exchanger consists basically of high-density polyethylene (HDPE) piping heat fused into circuit assemblies (U-tube or equivalent fitting assembly as noted) with runout connections forming the GHX circuits for the vertical GHX described in the Drawings and Specifications.

.2 The Contractor is responsible for the actual cost of drilling on the Site based on the chosen equipment and drilling methodology.

.3 The Contractor is responsible to manage all water and drill cuttings produced.

.4 Flushing, purging and filling of the closed-loop GHX is the Contractor’s responsibility. Prior to connecting the GHX to any building systems the Contractor must coordinate with the mechanical trade to ensure there is no external contaminants introduced to the GHX. All fluid chemicals must be supplied by the same manufacturer in order to avoid incompatible inhibitors and chemicals.

.5 The Contractor is required to attend a preconstruction site meeting with the Consultant and Owner’s representative to coordinate installation of the GHX and its components.

.6 The Contractor is responsible for obtaining any and all necessary permits to construct the GHX, including compliance with the Environment Protection Act, Ontario Regulation 98/12, and any other applicable local codes and regulations. The Contractor must also assist the Owner as necessary in obtaining the building permit,

including providing all supporting information required to comply with any regulations relating to geothermal installations, to the satisfaction of the local building authorities.

.7 The Contractor is responsible for all costs related to maintaining the work plan, including delays of up to 24 hours due to venting of any natural gas found on-site during drilling.

.8 Coordinate the installation of GHX with site services around the GHX. Locations of utilities and services that may be shown on the Drawings or in the Contract Documents are for information purposes only. Inquire with local utilities to obtain proper clearances.

.9 The contractor is responsible for protecting and/or restoring all landscaping and other existing conditions on and off the site resulting either directly or indirectly from the installation on of the GHX. Refer to section 1.11 below.

1.5 Intent

.1 This Section of the Specifications is intended to define the Contractor's scope of work, establish the quality and safety requirements, and set general precautions to protect further construction of the Project. Provide in the best available quality incidental items not specified herein or not shown on the Drawings but which are required and necessary to complete the work described in this Section.

1.6 Work completed by others

.1 Provide by others or as stipulated in the Contract Documents any Work not directly relating to the installation of the Closed-Loop GHX, as described in this Section and the Drawings

.2 The point of connection between the GHX and the building mechanical system is the GHX manifold isolation valves, whereby the geothermal contractor provides the manifold, isolation valves and the GHX flush ports. All piping from the GHX manifold isolation valves to the GHX headers is provided by the geothermal contractor. The mechanical piping connecting the mechanical system, including interior piping, heat pumps or chillers, heat exchanger(s), circulation pumps, and mechanical flush ports, to the GHX isolation valve is to be completed by the mechanical contractor.

Provide temperature and pressure gauges for measuring the ground loop fluid, to and from the GHX header.

1.7 Specific items to be furnished by the contractor

.1 Furnish all labour, supervision, proper equipment in good working condition, supplies, tools, and materials required to complete the work specified in this Section.

.2 Provide all safety equipment to meet the requirements of all applicable local, Provincial and Federal codes and applicable standards.

1.8 Delivery, storage and handling

.1 Store pipe and fittings on Site in designated area that will not interfere with the operations of the Owner or the operation of the other contractors at the Site.

.2 All pipes are to be sealed from the manufacturer with fusion welded or pressure fitting end caps, to the satisfaction of the Consultant, to prevent debris, rodents and other foreign material from entering the piping system. Handle all closed loop components in such a way as to eliminate the chance of internal contamination during storage and installation. Pipe and fittings integrity and cleanliness are a priority for the closed loop GHX system.

.3 Do not contact pipe with oil based material of any kind.

.4 All fittings are to be stored on site in sealed bags to prevent contamination with dirt, debris and other potential contaminants.

.5 Lock and secure equipment and storage areas. The Owner shall not be held responsible for loss of or damage to any of the Contractor's equipment, tools, materials or personal effects.

1.9 Materials and workmanship

.1 Maintain consistent quality control to assure compliance with the manufacturers’ recommendations and this Section.

.2 Provide materials that are new, of the type and quality specified herein and on the Drawings, and be free from all defects of materials or workmanship that would adversely affect performance or service life of the installed Work, or which would cause unsightly appearance.

.3 The Consultant has the right to inspect material at any time after delivery to the Site. Any material that is damaged, defective, or does not meet requirements of the Contract may be rejected, and corrected or replaced at no additional cost to the Owner

1.10 Quality control

.1 The Owner, under consultation with the Consultant may, at any time, suspend any portion of the Work when satisfactory results are not being met or when results are doubtful.

.2 The Work will not proceed after suspension until the Contractor makes necessary corrections to bring Work into compliance. The Contractor is not entitled to additional compensation or an extension of time for the performance of this Contract in the event Work is suspended due to contractor noncompliance or inability to produce satisfactory results according to the work of this Section.

.3 The Consultant has the right to disrupt work and remove destructive samples from the installed pipe to inspect and test any completed fusion weld, with no compensation due to the Contractor.

.4 Afield inspection of the GHX must be performed by the consultant prior to backfill.

1.11 Site restoration and cleanup

.1 The work site is to be kept clean and orderly at all times during the Work. Upon completion of the Work, repair any damage caused by equipment, remove all equipment, tools, materials, containers and debris and leave the project and staging area free of rubbish, protective materials or excess materials of any kind.

.2 Contain and dispose of all wastes generated according to local, provincial, and Federal regulations. At no time may any materials of any kind be disposed of onsite by burial or any other means.

.3 Protect trees, grass, parking surface, sidewalks or other existing features that may be exposed to damage during construction. Any repair or replacement required as a results of the installation work shall be the sole responsibility and cost of the Contractor.

1.12 Quality assurance

.1 Contractor's Qualifications

.1 A minimum five (5) years of experience in similar geothermal projects to this Project is required, with an established resume of successful installation experience on projects with closed-loop GHX of similar size and scope to that required for this Project. Such qualifications, references and proof of past projects shall be submitted.

.2 Provide proof of current accreditation with associated fusion card or certificate from a major HDPE pipe vendor or distributor. Personnel without current accreditation are prohibited from work on this Project.

.2 Manufacturer's Qualifications

.1 Firms regularly engaged in the manufacture of closed-loop GHX installation and construction products and tools of the types, material and size required; whose products have been in satisfactory use in similar service for not less than five (5) years.

1.13 GHX identification

.1 Provide a means to identify the location of the GHX outside circuit piping (identifying the footprint of the GHX field), supply and return headers and supply and return runout piping using either purpose built metallic tracer tape or tracer wire located at the same depth of the obvert GHX runout pipe elevations.. Provide tape that is highly resistant to alkalis, acids, and other destructive agents found in the ground at a depth of 300 mm to 450 mm (12 in. to 18 in.) below finished grade.

1.14 Shop drawings

.1 Submit Shop Drawings, product data and samples (if required) for review.

.2 Submit the following for review:

.1 List of contractor qualifications, including:

.1 Firm's experience including list of similar projects with references

.2 Installer and fusion certification for all personnel

.3 Description of drill rigs (i.e. type of drilling equipment) and number committed to this project

.4 Description of grouting equipment and capacity

.5 Description of flushing equipment and capacity

.6 Confirmation of Environmental Compliance Approval (ECA) relating to the construction, alteration extension or replacement of vertical closed loop ground source heat pumps as defined in O. Reg 98/12 made under the Environmental Protection Act (EPA).

.2 Sample logs:

.1 Drilling log

.2 Grouting log

.3 Pressure test log

.3 Full descriptive material and Shop Drawings:

.1 HDPE Pipe

.2 Borehole pipe assembly including U-bend

.3 Bentonite grout

.4 Sand

.5 HDPE Pipe fittings

.6 Manifold pipe

.7 Pipe & valve insulation

.8 Pipe & valve jacketing

.9 Manifold fittings

.10 Manual shutoff valves

.11 Balancing valves

.12 Control valve

.13 Pressure & temperature gauges

.14 P/T ports

.15 Pipe penetration sleeves

.16 Pipe penetration sealing device

.17 Heat transfer fluid

.4 Test reports for:

.1 Grout mixture

.2 Water treatment

.5 Submit Shop Drawings according to the requirements of Section 01 30 00.

1.15 Close out documents

.1 Completed As-Built Drawings to illustrate the location of all GHX components precisely located using GPS coordinates or certified surveyor. Locates shall be noted for all circuits, the full extent of all trenches as well as the building entry point. Provide record drawings and operation and maintenance manuals, format of each is outlined in Division 01. The Contractor is responsible to maintain As-Built Drawings and at project completion produce record drawings on the basis of the As-Built Drawings.

.2 Maintain full drilling logs for each borehole and supply same to the Consultant with close out documents or upon request. Include all drilling details such as type of soils, depth, presence of water and flow rate, type of drilling fluid, size of drill head, size of pull back reamer, length of borehole, the nature, location of any obstructions or encumbrances found, and general penetration rate during drilling in the drill logs.

.3 Maintain detailed pressure test logs for each runout circuit and section of pipe, with pressure readings as well as dates and times. Beginning and end readings of pressure logs shall be witnessed and signed by the Consultant or designated representative prior to backfill.

.4 Document the installation of the GHX field using a digital camera. Photograph all trenches prior to backfill, with as many photographs as required to clearly show all boreholes and pipes of the completed assembly clearly. Make Digital photographs available to the Consultant upon request.

.5 Submit a laboratory testing report confirming the concentration of the fluid and suitable chemical balance after all pipes have been flushed and filled with specified fluid concentration.

.6 Submit a balancing report confirming pressure drop and associated flow rates as specified for each runout. Balancing must be performed by a certified balancer.

.7 Submit supplier and manufacture warranties, guarantees, and certifications Division 01 and the General Conditions of the Contract, including those described in this Section.

.8 Supplier and manufacture warranties, guarantees, and certifications.

1.16 Warranty

.1 The Contractor warrants the work of this Section for a period of 2 years from Substantial Performance of the Work against defects and/or deficiencies according to the General Conditions of the Contract.

.2 The Pipe Manufacture shall provide a minimum warranty of fifty (50) years from Substantial Performance of the Work, non-prorated, fully transferable.

.3 Promptly correct any defects or deficiencies which become apparent within this warranty period, to the satisfaction of the Consultant and at no additional cost to the Owner. Defects include but are not limited to fluid leakage, soil settling/ erosion, performance degradation.

2 Products

2.1 Materials and products

.1 Provide new piping materials and factory-fabricated piping products of size, types, pressure and temperature rating and capacities as indicated.

2.2 HDPE pipe and fittings

.1 Only HDPE pipe and fitting material are acceptable for use.

.2 Meet the requirements of CSA B137.1

.3 All pipe and heat-fused material shall be manufactured from PE compound with the minimum cell classification of 345464C or 345464E as defined in ASTM D3350 (complete with minimum 5-year UV stabilization declared by the pipe manufacturer)

.4 All pipe and heat-fused material shall be manufactured from virgin polyethylene extrusion compound material according to ASTM D-2513, Sections 4.1 and 4.2. Pipe shall be manufactured to outside diameters, wall thickness and respective tolerances as specified in ASTM D-3035-93

or D-2447. Pipe material must be purpose-milled for closed loop ground heat exchanger applications, with applicable documentation from the manufacturer with warranty confirming product compatibility with these requirements.

.5 The HDPE SDR 11 material shall maintain a 1,392 kPa (202 psi) Hydrostatic Design Basis at 23°C (73.4°F) per ASTM D-2837, and shall be listed in PPI TR4 as a PE4710 piping formulation. The material shall be a high-density extrusion compound having a minimum cell classification of PE345464C or higher as specified in ASTM D-3350 with the following exceptions: this material shall exhibit zero failure (F0) when tested for a minimum of 192 hours under ASTM D-1693, condition C, as required in ASTM D- 3350.

.6 Plastic insert type fittings are not acceptable.

.7 Fittings shall meet the requirements of ASTM D-2683 (for socket fusion fittings) or ASTM D-3261 (for butt/saddle fusion fittings), or ASTM F1055 (for Electrofusion fittings).

.1 Fittings shall indicate the CSA Standard number “C448”

.2 Fittings shall not carry the word “potable” or the letters “P” or “PW” on their surfaces.

.8 All pipe sizes shall be manufactured according to ASTM D-3035 with a dimension ratio (DR) of 11, as specified below for the different pipe sections. **Pipe made with PE 3408/ PE 3608 resin is not acceptable.**

.9 Use PE410 pipes resin formulation. Use DR11 (202 psi/ 1.390 kPa) piping only.

.10 Meet the cell classification 345564 or 345434 as specified in ASTM Standard D 3350.

.11 Borehole circuit piping shall be manufactured to the project specific length (i.e. borehole depth plus 15 to 25 feet of additional pipe) with factory installed, single piece U-bend assembly. Each pipe set shall be factory pressure tested and shipped with a fusion welded cap under pressure to ensure integrity until installation.

.12 All pipe must be labelled by the manufacturer with suitable markings.

.13 Pipe shall be marked according to CSA B137.1 and shall indicate the intended service as “Geothermal” or “Geo”, the CSA Standard designation, “C448”, and the pipe cell classification.

.14 Pipe shall not carry the word “potable” or the letters “P” or “PW” on its surface.

.15 Sufficient information, including numerical markings every 600mm (2 ft.), shall be permanently marked on the length of the pipe. This information is defined by the appropriate ASTM pipe standard. All fittings shall also be similarly marked. Marked information shall include:

.1 Manufacturer's Name

.2 Nominal Size

.3 Pressure Rating

.4 Relevant ASTM Standards

.5 Cell Classification Number

.6 Date of Manufacture

.16 Pre-manufactured pipe sets shall have factory impressed/ printed length markings on the side of the piping indicating the length of the heat exchanger to that point; one pipe shall be marked from zero to the maximum length of pipe, while the other pipe shall be marked opposite from the maximum length to zero.

.17 Ensure the pipe manufacturer provides a minimum warranty of fifty (50) years from Substantial Performance of the Work, non-prorated, fully transferable.

2.3 Pipe joining methods

.1 The only acceptable method for joining the buried pipe system is by a heat fusion process. The fusion technician shall be properly trained and shall be able to demonstrate quality fusion joints consistently.

.2 Joining shall be by the socket (not greater than 2 in. nominal pipe diameter), butt, or electrofusion method according to the pipe manufacturer's procedures. Side saddle fusion shall not be permitted.

2.4 Interior pipe fittings

.1 Supply and Return manifolds shall be HDPE and constructed according to the Drawings, including specific fittings where noted thereon. Welded steel manifolds are permitted only with prior approval from the Consultant with a detailed submittal/ layout drawing submitted for review. Each manifold header shall include the following as noted in the Drawings.

.1 Isolation Valve: Each manifold shall have a single butterfly valve with a flanged connection as indicated in the drawings separating the GHX piping form the building loop piping. Wafer style valves are not acceptable. Valves shall be suitable for dead end service, have ductile iron body, aluminum bronze or stainless steel disc, stainless steel shaft and taper pin, EPDM seats, Teflon bushing, removable lever handle and 10 balancing stops, and extended neck to clear insulation.

.2 Temperature indicators: dial or linear type, aluminum or steel case, 2 percent mid-scale accuracy, black figures on white background, to be installed in thermowell for ease of replacement. Thermowell to be long enough to reach centre of flow at minimum. Install and angle gauge such that it may easily be read from floor level.

.3 Pressure Gauge: 4 inch diameter in drawn steel case, phosphor bronze Bourdon tube, rotary brass movement, brass socket and 1 percent mid-scale accuracy with front recalibration adjustment, black figures on white background, brass needle or gate valve and pulsation damper, and brass syphon for stem service. Install such that gauge may be easily read from floor level.

.4 Butterfly Valves: Lug-style stainless steel butterfly valve with flanged connections, including one piece resilient seat with a molded-in (integral) o-ring seal. Connect to flanged HDPE to steel transitions as indicated in the drawings. Valves shall be two piece shaft design, stainless steel disc, EPDM seat material, 10 position lever.

.5 Circuit Balancing Valves: Cast iron body with integrated flanges. Valve stem and plug disc shall be bronze with ergonomically designed hand-wheel that permits multi-turn adjustments. Flange adapters shall be supplied, to prevent rotation. The valve shall be installed with flow in the direction of the arrow on the valve body

and installed with appropriate pipe spacing from adjacent fittings. Armstrong CBV or approved alternate.

.6 P/T Ports: Each runout connection shall have installed where indicated on the drawings a ¼ in. MPT fitting to receive either a temperature or pressure probe of ⅛ in. outer diameter. Fitting shall be installed using acceptable fusion fittings with brass adapters as required; field installed pipe openings are not acceptable. Fitting shall be solid brass with two valve cores of neoprene (max 200 °F) at 500 PSI, and fitted with cap strap with gasket, and shall be rated at 1000 PSI at 140 °F.

.7 Additional Fittings: Additional fittings will be required for proper connections and manifold assembly. Where HDPE fittings are indicated in the drawing, products shall conform to the specifications herein. Where metal fittings are indicated in the drawings, all connections shall use the same material (i.e. brass, stainless steel) due to differing coefficients of expansion.

.2 Clearly label each of the runouts as shown on Drawings with runout letter – circuit #.

2.5 Insulation

.1 Provide insulation on all indoor piping, including supply and return manifolds.

.1 All insulation materials shall meet requirements of applicable cUL and NFPA Standards, and unless otherwise specified, all insulation system materials inside the building must have a fire hazard rating of not more than 25 for flame spread and 50 for smoke developed when tested according to CAN/ULC-S102.

.2 All indoor piping, valves, and fittings up to and including the manifold headers and GHX mains shall have ½ in. rigid insulation and PVC jacketing. Insulation shall continue on supply and return runout piping above ground up to the building penetrations.

.3 Pipe insulation at hangers and supports: factory made insulation pieces, each consisting of longitudinally split phenolic foam insulation of a thickness to match the adjacent insulation, a vapour barrier jacket with overlap flap, and an integral steel shield.

.4 White PVC fitting covers: Factory pre moulded, one-piece PVC fitting covers, minimum 15 mil thick, white, 25/50 rated with a semi-luster finish.

.2 Where pipes penetrate the building foundation at building entry point install closed cell spray foam insulation (suitable for burial), 2 in. in thickness around all piping to a minimum of 5 ft. horizontal distance from the building penetration. If pipes are less than 5 foot depth, an additional 2 in. of insulation is required.

.3 Rigid, type 2 insulation, 2 in. thickness should be installed where required to provide thermal break or insulation for trench pipes and as shown on drawings.

.1 Supply and return pipes to maintain minimum 12 in. separation at all times to ensure there is no thermal interference; should minimum separation not be possible rigid insulation may be installed.

.2 Maintain 5 ft. depth to top of pipe for all runout trenches; should minimum depth not be possible rigid insulation may be installed.

2.6 Wall, floor, and ceiling penetrations

.1 For all building penetrations a watertight seal is required using modular, mechanical type seals, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening. Manufactured by Link Seal or approved alternate.

.2 For standard service applications where only a watertight seal is required (all exterior penetrations) each modular seal shall be made from EPDM rubber with service temperature range of -40 °F to 250°F.

.3 For penetrations newly constructed concrete walls, a non-metallic insert with integrally formed water stop shall be installed prior to pouring the concrete into the wall forms. Insert shall be appropriately sized for the modular seal.

.4 Ensure that fire ratings of floors and walls are maintained. Where pipe passes through a fire separation, or as indicated on the drawings a seal consisting of a firestop material shall completely fill the annual space between the pipe and the wall opening. Seal shall meet the requirements

of the building code, the appropriate cUL/ULC system number, and match the fire rating of the fire separation.

2.7 Pipe hangers and supports

.1 All pipes, including manifolds, must be properly supported with hangers connected to floor, wall or ceiling structures. Do not use pipe material and wall openings as support.

.2 All hangers and supports must comply with mechanical specification where applicable.

.3 Hangers:

.1 Load bearing surface must be free of any rough or sharp edges that could damage the pipe.

.2 Hangers must not restrict linear movement of the system due to thermal expansion and contraction of the pipe.

.3 Hanger rods shall be threaded at both ends, or continuously threaded rods with circular cross sections, using adjusting locknuts at upper attachments and hangers. Wire, chain, or perforated straps are unacceptable

.4 Pipe Clamps shall have weld less eye nuts.

.5 Wall Supports must be either welded strut bracket and pipe straps, or welded steel brackets, with roller chair or adjustable steel yoke pipe roll.

.6 Floor Supports must carbon steel type with adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation. Pipe saddle shall be screwed or welded to appropriate base stand.

.7 Vertical Supports must be steel riser clamp sized to fit outside diameter of the pipe.

.8 Concrete Inserts: Cast in place spot concrete inserts shall be used where applicable; either steel or malleable iron body. Spot inserts shall allow for lateral adjustment and have means for attachment to forms. Select inserts to suit threaded hanger rod sizes.

.9 Vibration Isolation and Supports

.1 Use neoprene or spring hangers as required to isolate all mechanical components, as well as for proper seismic bracing as required by Ontario Building Code or applicable local by-laws.

2.8 Heat transfer fluid

.1 Heat transfer fluid to be used is 25% by volume propylene glycol, premixed with suitable corrosion inhibitors by manufacturer. Mixture to have a freeze protection to -10ºC [14ºF].

.2 After glycol solution has been charged a fluid sample shall be taken and tested for water quality and concentration as per ASTM E202.

.3 It is the responsibility of the Contractor to coordinate with the interior mechanical contractor to ensure the fluid mixture and chemical inhibitors installed in the GHX are identical to the heat transfer fluid installed in the building piping system.

2.9 Trench backfill material

.1 All trenches to be backfilled using excavated spoils or other native soil. Soil within 305 mm (1 foot) radius surrounding pipes must be free of any rocks and abrasive material.

.1 Fill from excavated spoils may be used if fine grained (<200 sieve size), and shall include clean, natural or prepared soil with fines.

.2 Fine dirt fill from an off-site source may be used if spoils cannot provide proper bedding material. Fill shall include clean, natural or prepared soil with fines (up to 1ft. for bedding purposes).

.3 Large rocks and boulders greater than 610 mm (2 ft.) in diameter may not be used in the trench and must be removed from the site.

.4 Sand shall be used to provide smooth, continuous bedding for all horizontal runout pipes, with a minimum depth of 3 in. throughout. Native soils shall not be used for bedding.

.5 Additional sand shall be required where any pipes cross over each other, to provide a minimum 3 in. gap in between the pipes to avoid bridging.

.6 Avoid driving construction equipment over newly filled trenches unless bridging is provided to support load over trenches.

.7 If the trenches are located under an area that is to be paved or finished in anyway, the GHX contractor must coordinate their work with other Subcontractors to ensure that the trenches are backfilled and compacted to the specifications required for that scope of work.

2.10 Sleeves and openings

.1 Install non-ferrous pipe sleeves (i.e. PVC or similar) through foundation walls or floors where required to route pipes into and throughout the building.

.1 Seal openings using a manufactured mechanical seal device, Equivalent to Link-Seal or approved alternate.

.1 Location and size as required to maintain required fire rating of the assembly, as well as prevent moisture from entering through the opening.

.2 Pressure resistant to 20psig (40 ft. of head)

.3 Standard link construction EPDM rubber (black) or better to suit fire rating.

.4 Hardware S316 Stainless Steel

.2 Clearances between pipe on sleeves:

.1 6mm (¼ in.) clearance around sleeve and pipes, or between sleeve and pipe insulation (if applicable).

.3 Do not install piping below footings.

3 Execution

3.1 Examination

.1 Verification of Conditions: Verify actual site dimensions and location of adjacent materials prior to commencing work. Notify Consultant in writing of any conditions which would be detrimental to the installation.

.2 Evaluation and Assessment: Commencement of work implies acceptance of previously completed work.

.3 Contractor is responsible for identifying and locating any buried services prior to commencing work.

.1 Size, depth and location of existing utilities and structures as indicated are for guidance only. Completeness and accuracy are not guaranteed.

.2 Prior to beginning excavation work, notify the Consultant and establish location and state of use of buried utilities and structures. Utility representatives to clearly mark such locations to prevent disturbance during Work.

.3 Confirm locations of buried utilities by careful test excavations and/or soil hydrovac methods.

.4 Maintain and protect from damage, water, sewer, gas, electric, telephone and other utilities and structures encountered.

.4 Protect existing buildings and surface features from damage while Work is in progress. In event of damage, immediately make repair as directed by the Consultant.

3.2 Coordination

.1 Coordinate all Work activities with the Owner and Subcontractors and Suppliers as applicable.

3.3 Cleanliness

.1 During storage and installation, care must be taken to ensure no trash, soil or other debris is allowed to enter the pipe. Mechanically sealed caps must be used at all times. Visually inspect each circuit and runout pipe prior to installation to verify that no obstructions, kinks, abrasions or other damage exist.

.2 Take precautions to keep the site clean and contain all drilling fluids and materials within the immediate drilling area. At no time shall any water or materials pass beyond the site limits or be allowed to enter the municipal drainage system. The Contractor is responsible for complying with all local by-laws or regulation and responsible for disposing of any excess water.

3.4 Installation of components

.1 Drilling and Borehole Installation

.1 Drill boreholes according to all requirements for borehole drilling as prescribed by the appropriate governing body, and general industry

practice. The Contractor will be responsible for receiving, permission in writing from the governing body (if required) prior to proceeding, including submission of work plan and maintenance of drilling logs as required. Borehole installation may not proceed until the Contractor has provided permit or written confirmation of installation approval.

.2 Contractor shall carry an environmental compliance approval (ECA) relating to the construction of a closed loop ground source heat exchanger as defined in the O.REG 98/12 made under the environmental protection act (EPA). Contractor is responsible for all costs related to maintain the work plan, including delays of up to 24 hours due to venting of any natural gas found on-site during drilling.

.3 The borehole shall be of sufficient diameter to facilitate the installation of a complete pipe circuit (i.e. supply and return portion of the sub-circuit)

.4 All trenches and piping to be a minimum of 1.5m [5’] form property lines and building structures.

.5 No petroleum based products are to be in contact with HDPE pipe.

.6 Do not to crush, cut or kink the pipe during installation. If damaged, remove pipe and install new circuit pipe. Do not repair damaged borehole pipes with a fusion coupling or any other means.

.7 Immediately after completion of the horizontal borehole the pre-tested pipe assembly shall be installed into the completed borehole. Do not leave borehole open for more than two hours after drilling is complete.

.8 The Contractor is responsible to manage, maintain, and dispose of all drilling fluids and spoils produced during the drilling process. Borehole logs indicated on drawings are for reference purposes only; cost to manage all water produced is the responsibility of the Contractor, regardless of volume, and in compliance with the OBC and other applicable codes, standards and regulations that are referenced in this Section or otherwise apply to the work of this Section.

.1 Unless specifically approved to use another process, use frac tanks or similar device to discharge and contain all

drilling cutting, fluids and any water produced during the drilling process. Use of retention ponds must be approved in advance by the Consultant and requires detailed coordination to avoid impacting construction operations.

.2 Contain drilling fluid/water to the project site, and not be allowed to accumulate anywhere on the project site and surrounding area. Any fluid accumulation must be managed and disposed of immediately in compliance with local regulations.

.2 Fusion Work

.1 Socket fusions (not greater than 50mm [2”]), butt fusion, or electrofusion, as per manufacturers instruction, are the only acceptable methods of joining HDPE pipe.

.2 Install the GHX circuits and connections in a pattern as indicated in the Drawings.

.3 Equipment must be maintained in safe, reliable condition, and maintain heater faces in clean condition.

.4 No open pipe ends are to be left unattended at any time. Use fusion welded HDPE end caps or barbed straight plugs to permanently seal any open pipe ends. Tape or loose fittings caps are not permitted.

.5 Fusions are to be performed by accredited fusion installers.

.6 In order to complete proper joining, the Contractor shall have available on-site the following tools: iron at proper temperature, chamfering tool, cold ring clamps, clean 100% cotton rags, isopropyl alcohol, timer or watch, temperature measurement device (in addition to the heating irons built in thermometer), and a permanent marker (not Black).

.7 Fusion equipment must be tested routinely during fusion work to demonstrate proper heater face temperature. A pyrometer (digital or analog) with proof of calibration is required for each fusion crew. Temperature stick crayons may be used for occasional testing but a digital pyrometer test is required for daily baseline testing.

.8 Example fusion samples from the installed piping circuits or from scrap pieces may be taken from site for destructive testing at the

Consultant's discretion without compensation to the Contractor. Replace any fittings removed in order to complete the installation as designed.

.9 Visually and physically inspect each joint, using industry standards, for cold joints. Any joints failing the test shall be completely removed from the system and a new joint or fitting installed with the test being repeated.

.10 Pipe and fitting manufacturer's recommendations for time and temperature requirements shall be followed strictly at all times, regardless of weather or other conditions.

.11 Do not install fusions between two fittings or pipe sections with SDR ratings that differ by 5 or more (i.e. a fitting of SDR 17 may not be fused to a pipe of SDR 11 even if both SDR ratings are permitted for use for this project).

.3 Pipes in Trenches

.1 The quantity of fusion joints in the system shall be kept to a minimum based on the specified details.

.2 The minimum bend diameter shall be determined by the following: Minimum Diameter = Pipe O.D. (actual) x 20. It is preferable to have larger bend diameters, and it is typically 30 times the actual pipe outside diameter or greater.

.3 Use only continuous lengths of pipe in bends. Install elbow fittings for required bends which are tighter radius than calculated above.

.4 Use reducing fittings at all specified locations to facilitate the removal of air during flushing. Use reducing tees and pre-fabricated reducing type close headers.

.4 Wall, Floor, And Ceiling Penetrations

.1 Coordinate penetrations through concrete walls and other structures with the General Contractor to ensure they are properly located and supported. Seal piping at all wall penetrations as noted on the Drawings.

.2 Adequate spacing shall be provided to allow supply and return runout lines to enter manifold in a neat and orderly manner, parallel

to one another. Use of flexible connections or hoses is not permitted.

.3 Maintain integrity, water resistance, and fire rating of the wall, floor, or ceiling construction as specified.

.4 Below grade piping must be protected from shear stress due to soil shifting or settling. Where horizontal piping penetrates a below grade structure, all soils below piping must be compacted to 100% proctor density.

.5 Pipe Hangers and Supports

.1 Support pipe installed in the building by specified pipe hanger and supports.

.2 Support indoor horizontal piping according to the table below:

Pipe Size (in.)	Rod Diameter (in)	Maximum Support Spacing (ft.)
3	½	7.0
4	⅝	7.5
6	⅝	9
8	¾	9.5
10	⅞	9.5

.3 Install hangers to provide a minimum of ½ in. space between finished covering and adjacent work.

.4 Place a hanger within 12 in. of each horizontal elbow.

.5 Place a hanger within 12 in. of any concentrated stress loads (e.g. valves, flanges, and any other heavy system components.

.6 Support for vertical piping shall be independent of support for connected horizontal piping.

.7 Do not support piping from other pipes, ductwork or other equipment that is not part of the building structure.

.8 Add seismic bracing as required to comply with local codes.

.6 Provision for Pipe Expansion, Contraction

.1 Make provision for pipe expansion, contraction and building shrinkage with suitable anchors, offsets or expansion loops. Where space limitations do not permit the use of expansion loops or

offsets, provide expansion joints properly selected for system operating pressures. Do not use standard grooved joint fittings for expansion/contraction compensating purposes.

.2 Install piping to allow freedom of movement in all planes without imposing undue stress on any section of main piping, branch piping, equipment or structure.

.3 Install expansion joints according to manufacturer's published instructions.

3.5 Earthwork

.1 All excavation and backfill to comply with recommendations in project geotechnical report.

.2 Excavate the trenches for horizontal closed-loop GHX runout piping with a backhoe or other acceptable excavation device.

.3 Perform all shoring and sheeting that is required to protect the excavation and to safeguard employees according to applicable safety standards and local building code. Widen excavation to provide for space occupied by shoring and sheeting.

.4 During excavation, deposit material suitable for backfill in an orderly manner, a sufficient distance from the excavation banks to avoid overloading and to prevent slides or cave-ins. Contractor is responsible to follow safe work procedures to the satisfaction of the local authority.

.5 Grade as necessary to prevent surface water from flowing into trenches or other excavations, and remove water accumulating therein by pumping or other acceptable method.

.6 Unless otherwise indicated, excavation shall be by open cut. With the exception of shoring requirement, keep banks of trenches and excavation for structures as nearly vertical as practicable and where required, properly sheet and brace.

.7 Ensure that un-authorized personnel cannot access the trench. Appropriately fence and lock unsupervised trenches.

.8 Excavate true to line to a depth as shown on the drawings. Grade bottom of trenches accurately to provide uniform bearing and support for each

section of pipe. Minimum 3 in. of sand along its entire length shall be provided to bed pipes.

.9 All trenches shall utilize excavated sloped ramps instead of ladders or other mechanical devises for easy, safe access and egress of installation personnel.

.10 Make provisions to prevent surface water and subsurface/ groundwater from accumulating within the trenched areas. Any standing water must be immediately pumped out to suitable discharge area.

.1 Remove water to prevent softening of foundation bottoms, undercutting footings and soil changes detrimental to stability of sub-grades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines and other de-watering system components necessary to convey water away from excavations.

.2 Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or runoff areas. Do not use trench excavations as temporary ditches.

.11 Backfill trenches to final grade elevations in uniform layers no greater than 24 in. compacted thickness. Compact each layer to 98% standard proctor density unless otherwise specified by geotechnical engineer. Refer landscape and civil plans for proper elevations.

.12 Dispose of surplus and unsuitable excavated material off site.

.13 Excavation must not interfere with bearing capacity of adjacent foundations.

.14 Do not disturb soil within branch spread of trees or shrubs that are to remain. If excavating through roots, excavate by hand and cut roots with sharp axe or saw.

3.6 Sleeves

.1 Sleeve pipes where they pass through floors, walls, partitions and ceilings and shall be concentric with pipe. Increase the sleeves diameter to accommodate the pipe insulation where applicable.

.2 Produce a dimensional drawing locating sleeves and openings in poured in place concrete. Should any sleeve be omitted or incorrectly located, include or relocated sleeves at no additional cost to the Owner.

.3 Terminate sleeves extended minimum 2 in. beyond finished surface of floor or wall.

.4 Firmly seal space between pipes and sleeves with mechanical seal to prevent any moisture transfer.

.5 Ensure that there is no direct contact between pipe and sleeve at any point.

3.7 Hydrostatic pressure testing

.1 Use a hydrostatic pressure test for all pressure tests. Air pressure tests are not permitted.

.2 When all pipe circuits are complete and connected to the building manifolds pressure test the entire system for a minimum of 48 hours.

.1 Pressure test each individual runout/pipe circuits for a minimum of 24 hours prior to backfill as an interim test, with date/ time logs completed on each for verification.

.3 Notify the consultant at least two (2) business days prior to the start of the final pressure test. Both the start and end of the all pressure tests must be witness by the Consultant or designated representative.

.4 Pressure testing shall be done in accordance to ASTM F-2164 which is considered standard practice for field leak testing of polyethylene pipe. All safety precautions noted in ASTM F-2164 shall be observed and considered before conducting the pressure test as a failure could lead to a sudden and uncontrolled movement of any unrestrained piping and cause serious injury to bystanders.

.5 Pressure Gauge: Use the same pressure gauge to measure the initial and final pressures. The pressure gauge shall have radial movement, and 2% accuracy. The maximum range of the pressure gauge shall be no less than 120 psig, and no more than 200 psig.

.6 Ensure all piping is restrained. Fill piping with water and bleed off any trapped air. Allow water to reach ground temperature, and then proceed to initial expansion phase.

.7 Gradually increase the piping circuit to the desired test pressure of 690 kPa (100 psig) over time to account for pipe expansion. During the initial expansion of the pipe undergoing testing, sufficient make-up water must be added to the system at hourly intervals to maintain the test pressure; initial expansion should be complete after approximately four (4) hours, at which time the actual test can start.

.8 Test phase: Ensure pressure within the pipe is 690 kPa (100 psig). Once a minimum of 48 hours has elapsed, measure the pressure of the pipe. To prove the system has no leaks, the final measure pressure must be within 5% of the pressure measured at the start of the test.

.9 Visually and physically examine every weld/fusion during the test to ensure no leaks, kinks, obstructions, or abrasions. Visibly initial each weld/fusion with a permanent, visible marker.

.10 If any leaks or damaged pipe are detected the piping shall be safely depressurized, and that pipe section shall be cut out and replaced, at which time the runout circuit shall be re-tested according to this section.

.11 Refer to the manufacturer's specifications for allowable pressure changes due to thermal expansion/contraction for pressure test.

.12 Pressure test and visual log must be completed by the Contractor prior to backfilling the trenches.

.13 Upon completion of the pressure test, the pressure inside the pipe shall be reduced to 30 psig until connections to the manifold are completed. Do no leave any completed section of pipe without pressure.

3.8 Flushing and purging

.1 Flushing shall be performed at various stages throughout the installation process to flush air and debris from the system and introduce clean water to the piping.

.2 Use a purpose-built purge pump (not the designated system pump):

.1 Purge Pump – the pump must be capable of pumping at the minimum circuit flushing flow rate as specified on the drawings, at a minimum pressure drop as specified on the Drawings plus the pressure drop of the connecting hoses at a minimum flow rate of 3.3 l/s [53 USGPM] at 114 KPA [38 ft. of w.c.] for each 75mm [3"]

diameter runout pipe is required for flushing and purging of the horizontal ground heat exchanger before commissioning, based on minimum temperature of 10°C (50°F).

.2 Fluid reservoir

.3 Filter Assembly or bag filter (minimum 5 micron).

.4 Flow meter

.5 Pressure Gauge

.6 Connecting Piping

.7 Connecting Hoses – minimum hose size 51 mm (2 in.). Each hose will have shut-off valve to allow full control of the flow through the system.

.3 If any borehole pipes are found to be improperly capped during installation or if there is any evidence of damage to the pipes during the construction period, each individual borehole pipe must be individually flushed and pressure tested to ensure its integrity. Flushing and testing procedures to be determined at the sole discretion of the Consultant based on the evidence of damage and potential risk to the system performance.

.4 When each pipe circuits has been fully assembled and positioned in the trenches it shall be individually flushed, purged of air, and pressure tested

.5 Once the complete system is installed, including the manifolds, a final flush shall be performed from the flushing ports located in the mechanical room. Each supply and return runout pair of the GHX shall be flushed individually by closing the valves to all of the other runout pairs. In this manner, each circuit will be flushed separately. Each GHX runout shall be flushed at the minimum flushing flow rate specified on the drawings for a minimum of 1 hour. This will ensure a fluid velocity of greater than 0.61 m/s (2 ft./s) through each circuit.

.6 After 1 hour of flushing, the valve in the hose connecting the GHX to the purge pump reservoir shall be closed while the purge pump is operating, in effect “dead-heading” the pump. As the valve is closed the water level in the reservoir must be monitored. If the water level in the reservoir drops more than 25mm (1 in.) as the valve is closed, that is a sign that air remains in the horizontal GHX section being flushed. Flushing must continue until the water level drop is less than 25mm (1 in.) as the valve is closed. Repeat sequence in reverse flow flushing. Additional flushing is

required until filters on flush kit are free of debris. Images of clean filters once the flushing has been completed is required to be submitted to the Consultant for review.

.7 Total volume of the GHX system is 6,814 L [1,800 US Gal] of fluid. The volume calculation is intended as a guide only. Contractor is responsible to add additional fluid as required to maintain system pressure after Startup and throughout warranty period, including compliance with all specified fluid parameters.

.8 Utilizing the purging unit, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate blockage using manufacturer's recommendation, remove blockage, then re-purge and conduct the pressure and flow test again until all portions of the system are flowing properly. The flow test must be observed and approved by the Consultant or designated representative before the system is to be considered completed.

.9 The Contractor must provide proof of purge pump performance. Submit the manufacturer's pump curves or independent flow test provided by a recognized pump vendor, to the Consultant for approval prior to flushing the GHX.

3.9 Installing fluid

.1 Introduce water into the piping system and use to flush and purge the GHX. Potable city water is acceptable for the final charge only with proper chemical treatment.

.2 Introduce the antifreeze solution into the system after the system is flushed and purged to the required percentage as required to achieve the final concentration specified.

.3 After the GHX is flushed, purged and filled with the required fluid concentration, the system must be pressurized to 207 kPa gauge (30 psig) static pressure until commissioning.

.4 Take a sample of the heat transfer fluid from the system and have it tested by a third party to test the cleanliness and chemical levels of the fluid. Isolation valve between the GHX and the building piping may not be opened prior to review of the results of the test by the Consultant.

.1 Testing shall be completed after final charge by certified water treatment contractor and report issued to consultant confirming same.

.5 Clearly label the system with the type and concentration of fluid installed, with large, easily visible labels on the manifold and at the fluid fill connection.

3.10 Repair & restoration

.1 Protect existing site conditions (trees, buildings, and the like) where possible and fully restore the Site to its condition prior to completion of the Work.

3.11 Fluid balancing

.1 Ensure all GHX circuits are properly balanced by a certified fluid balancing contractor to achieve maximum flow rate of 2.5 l/s [40 USGPM] at 99 kpa [33 ft. of w.c.] for each 75 mm [3”] diameter runout pipe is required for operation.

3.12 Closeout activities

.1 Commissioning: The Contractor to provide any information requested by the Owner-appointed Commissioning Agent and participate in onsite meetings as required to complete specified commissioning procedures.

.2 Training & Demonstration: The Contractor shall direct building operation staff on all procedures necessary to operate and maintain the GHX as installed.

End of section

1 General

1.1 Section includes

.1 Ductless split air conditioning systems.

1.2 Related requirements

.1 Section 20 01 00 – Mechanical General Requirements

.2 Section 20 05 00 – Common Mechanical Work Results

1.3 Reference standards

.1 Local and District By-Laws, Regulations and Published Engineering Standards.

.2 CAN/CSA - B52: Mechanical Refrigeration Code.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Provide catalogue data indicating rated capacity, dimensions, and service connections, electric nameplate data and wiring diagrams.

.4 Shop Drawings: Indicate layout of system and components.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 Warranty

.1 Provide five (5) year manufacturer warranty starting from date of Substantial Performance for compressors.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Air conditioning unit – split system

.1 General: CSA or Ontario Hydro Inspection approved, UL or ULC tested and ARI rated, and factory assembled with all controls installed, piped and wired

.2 Wall Mounted

.1 General: unit shall be suitable for use as indicated. Unit shall be supplied complete with cabinet, evaporator coil, drain pan, refrigerant line connections, blower cooling relay, expansion valve kit, blower, disconnect switch, and filter section.

.2 Capacities and Performance: as shown on drawings.

.3 Condensing Unit

.1 General: constructed with heavy gauge enamelled steel cabinet, complete with control box, outdoor fan, compressor, outdoor coils, suction line accumulator, expansion valve, crankcase thermostat, low ambient switch, high pressure switch, start controls, Hi-capacity two drier-check valve system, refrigerant line connections, electrical inlets and service valves, weatherproof disconnect switch, and insulated refrigerant line kit. (Less refrigerant)

.2 Capacities and Performance: as shown on drawings.

.4 Equipment Warranty: The compressor shall have a limited warranty for a full five (5) years starting from date of Substantial Performance. All other components shall have a limited Warranty for two (2) years starting from date of Substantial Performance.

.5 Start Up: Provide the service of certified manufacturer's representative during start-up and owner's instruction.

.6 Manufacturer: LG models indicated or approved alternate.

.7 Acceptable alternates, subject to shop drawing review:

.1 Sanyo;

.2 Carrier;

.3 Mitsubishi Electric;

.4 Daikin; or

.5 Oher approved alternate.

3 Execution

3.1 Installation

.1 Install indoor unit in accordance with manufacturer's installation instructions. Make all connections necessary.

.2 Install outdoor unit plumb and level on roof stand, minimum 300 mm above the finished roof level, making all necessary piping connections.

.3 Install refrigerant line kits in accordance with manufacturer's installation instructions.

.4 Refrigeration Equipment: prepare system for start-up by having manufacturer's field engineer or factory trained representative supervise testing, and charging of machines.

.5 Testing:

.1 Provide sufficient refrigerant, dry nitrogen and refrigeration oil for pressure and operational testing under manufacturer's supervision.

.2 Prior to testing ensure that system is complete. Protect relief valves during test procedure. After completion of test, reconnect and make good piping connections and leak test entire system.

End of section

1 General

1.1 Section includes

.1 Energy Recovery Ventilators (ERVs)

1.2 Related requirements

.1 Section 00 65 36 – One year extension of contract warranty period

.2 Section 20 01 00 – Mechanical General Requirements

.3 Section 20 05 00 – Common Mechanical Work Results

1.3 Reference standards

.1 ARI 270 - Sound Rating of Outdoor Unitary Equipment.

.2 ASHRAE 84-2013, Method of Testing Air-to-Air Heat/Energy Exchangers (ANSI approved).

.3 ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

.4 ASHRAE 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Section 20 01 00 – Mechanical General Requirements: Procedures for submittals.

.4 Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical

service with electrical characteristics and connection requirements, and duct connections.

.5 Product Data:

.1 Provide literature which indicates dimensions, operating weights, capacities, ratings, fan performance, gauges and finishes of materials, and electrical characteristics and connection requirements.

.2 Provide data of filter media, filter performance data, filter assembly, and filter frames.

.3 Provide fan curves with specified operating point clearly plotted.

.4 Submit sound power level data for both fan outlet and casing radiation at rated capacity.

.5 Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

.6 Section 20 01 00 – Mechanical General Requirements: Submittals for information.

.7 Submit manufacturer's installation instructions. Indicate assembly, support details, connection requirements, and include start-up instructions.

.8 Section 20 01 00 – Mechanical General Requirements: Submittals for project closeout.

.9 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

.2 ARI Compliance:

.1 Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.

.2 Comply with ARI 270 for testing and rating sound performance for RTUs.

.3 NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 Delivery, storage and protection

.1 Section 20 01 00 – Mechanical General Requirements: Transport, handle, store, and protect products.

.2 Protect units from physical damage by storing off site until roof mounting curbs are in place, ready for immediate installation of units.

1.8 Warranty

.1 Provide the following warranties:

.1 Two (2) years starting from date of Substantial Performance.

1.9 Maintenance service

.1 Section 20 01 00 – Mechanical General Requirements: Submittals for project closeout.

.2 Provide service and maintenance of packaged air handling units for one (1) year from Date of Substantial Completion.

.3 Provide maintenance service with a two (2) month interval as maximum time period between calls. Provide twenty four (24) hour emergency service on breakdowns and malfunctions.

.4 Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of six (6) filter replacements, minimum of one (1) fan belt replacement, and controls check-out, adjustments, and recalibration.

.5 Submit copy of service call work order or report, and include description of work performed.

1.10 Extra materials

.1 Section 20 01 00 – Mechanical General Requirements: Submittals for project closeout.

.2 Provide one (1) set of filters.

2 Products

2.1 General

.1 Comply with ASHRAE 84.

.2 The following manufacturers are approved in principle subject to meeting the specifications. Manufacturers are responsible for all co-ordination issues arising from dimensional variances between plans and site conditions: Daikin, Innovent, Ventrol, or approved alternate.

.3 Air handling units shall be ETL-Canada safety listed to conform to UL Standard 1995 and CAN/CSA Standard C22.2 No. 236. Air handling unit glycol heating coil shall be certified in accordance with the forced circulation air cooling and air heating coils certification program, which is based on ARI Standard 410.

2.2 Casing

.1 Fabricate unit with 16 gauge nominal channel posts and panels secured with mechanical fasteners. All panels and access doors shall be sealed with bulb-type gasket.

.2 Panels and access doors shall be constructed as a 2-inch (50-mm) nominal thick, thermal broke double wall assembly, injected with foam insulation for an R-value of not less than R-13. The outer casing shall be constructed of G60 galvanized steel, phosphatized and painted with baked on enamel.

.3 The inner liner shall be constructed of G90 galvanized steel. Panel deflection shall not exceed L/240 at 125% of design static pressure, minimum +/- 8 in. Deflection shall be measured at the midpoint of the panel height.

.4 The casing leakage rate shall not exceed 0.5 cfm per square foot of cabinet area at 6 inches of negative static pressure or 5 inches of positive static pressure.

.5 Access doors shall be flush mounted to the cabinetry and secured with heavy-duty stainless steel hinges. The door latch handle assembly shall be provided with a full-size grip handle and roller pall for smooth operation. The assembly shall be gasketed and sealed to prevent thermal bridging. Provide inspection window for each access door.

.6 Outdoor units shall have a solid metal roof cap, intake hoods, exhaust hoods and piping vestibules. Piping vestibules shall be shipped loose for field installation by others. Provide roof curbs for outdoor units where shown on plans.

.7 All outdoor units mounted on roof curbs with openings to the conditioned space below, shall be designed with a drip shield under the unit to catch and remove any potential moisture created by condensation.

.8 Provide unit with an aluminum treadplate flooring in all access sections.

2.3 Outdoor air intake section

.1 Provide outdoor air intake sections with factory mounted low leak airfoil outside air dampers of galvanized steel in galvanized frame. Dampers shall be hollow core airfoil blades, fully gasketed. Provide continuous vinyl seals between damper blades. Provide stainless steel end seals along end of dampers. Provide linkage and ABS plastic end caps provided.

.2 Damper leakage rate shall be less than 73 m3/h per m2 (4 cfm per ft2) leakage at 1 inch static pressure differential. Leakage rate shall be tested in accordance with AMCA Standard 500.

.3 Provide fail-safe motorized damper actuator for open/close action with end switch.

.4 Rain hoods with birdscreen shall be provided for outdoor air intake and sized to prevent snow/rain entrainment.

2.4 Exhaust air outlet

.1 Provide factory mounted low leak airfoil exhaust air damper of galvanized steel in galvanized frame. Dampers shall be hollow core airfoil blades,

fully gasketed. Provide continuous vinyl seals between damper blades. Provide stainless steel end seals along end of dampers. Provide linkage and ABS plastic end caps provided.

.2 Damper leakage rate shall be less than 73 m3/h per m2 (4 cfm per ft2) leakage at 1 inch static pressure differential. Leakage rate shall be tested in accordance with AMCA Standard 500.

.3 Provide fail-safe motorized damper actuator for open/close action with end switch.

.4 Rain hoods with birdscreen shall be provided for outdoor air intake and sized to prevent snow/rain entrainment.

2.5 Filters

.1 Provide outdoor air and exhaust air filter box sections located on the inlet to the energy recovery device. Filter sections shall include filter guides, hinged and latching access doors on one side, for side loading of filters.

.2 Filter media shall be UL 900 listed.

.3 For the exhaust air stream provide flat arrangement with 2 inch deep MERV 8 pleated panel filter.

.4 For the outdoor air stream provide extended surface filter box with holding frames suitable for 2 in MERV 8 pleated panel prefilter and final filter, media and blank-off sheets, extended surface cartridge media filters with MERV 13 rating. Cartridge filter media shall be 12 in deep. 4 in secondary filters will not be accepted.

.5 Provide Magnehelic filter gauges for each filter bank flush mounted into unit casing with factory mounted probes.

2.6 Fans

.1 Provide air foil direct drive plenum fans as scheduled. Belt driven fans will not be accepted. Dynamically balance fans before and after installation in fan cabinet section. Ensure maximum fan RPM is below the first critical speed fan.

.2 Locate fan and motor internally on a steel base. Factory mount motor on a slide base that can be slid out of unit. Provide access to motor through

hinged access door. Provide fan and motor assembly 2 in deflection spring.

.3 Provide TEFC premium efficiency motors. Inverter duty rated motors shall be supplied with a factory installed shaft grounding kit. The kit shall consist of brushes or conductive rings with micro fibers which divert unwanted shaft currents away from the bearings to the ground.

2.7 Coils

.1 Provide access to coils from opposite connection side of unit for service and cleaning. Enclose coil headers and return bends fully within unit casing. Fabricate coil connections, vents and drains to extend beyond unit casing including gromments for an airtight unit casing. Coils shall be removable through side panels and/or top panels of unit without removal and disassembly of entire section.

.2 Coil performance shall be as per schedule. Coil performance data shall be certified in accordance with ARI Standard 410 where applicable.

.3 Construction:

.1 Tubes: Copper.

.2 Fins: Aluminum mechanically bonded to tubes.

.3 Headers: Seamless copper with vent and drain connections.

.4 Glycol heating coil shall be circuited drainable with a vent connection at the highest point and a drain connection at the lowest point. Coil headers shall be copper with steel male pipe connections.

2.8 Access

.1 Access sections shall be 14” deep. Provide access doors of galvanized steel flush mounted, with gasket, latch and handle assembly.

2.9 Energy recovery wheel

.1 Provide enthalpy wheels factory installed in units.

.2 Energy recovery wheel shall be constructed of alternate layers of corrugated and flat aluminum sheet material. Synthetic media wheels will not be accepted. All surfaces shall be coated or uniformly bound with a

non-migrating absorbent specifically developed for the selective transfer of water vapor.

.3 Media shall be engineered to provide corrosion resistance and resistance against attack from laboratory chemicals present in pharmaceutical, hospital, etc. environments as well as attack from external outdoor air conditions. The rotor media shall be capable of being cleaned with low temperature steam without degrading unit performance.

.4 The desiccant material shall be a molecular sieve, and specifically a 3A molecular sieve to minimize cross contamination.

.5 The wheel frames shall consist of evenly spaced steel spokes, galvanized steel outer band and rigid center hub. Adjustable brush seals must be provided along the periphery of the rotor and between the inlet and outlet air passages to effectively prevent air leakage and cross-contamination between airflows.

.6 Cassettes shall be fabricated of heavy duty reinforced galvanized steel or welded structural box tubing. Cassettes shall have a built in adjustable purge section minimizing cross contamination of supply air. Bearings shall be inboard, zero maintenance, permanently sealed roller bearings, or alternatively, external flanged or pillow block bearings.

.7 The rotor drive system shall consist of a self-adjusting belt around the rotor perimeter driven by an AC motor with gear reduction. The variable speed drive shall be specifically designed for heat wheel applications and include: an AC inverter, soft start/stop, rotation detection w/alarm contacts, automatic self-cleaning jog cycle, and self-testing capability. The speed controller shall be capable of accepting a potentiometer, VDC, or mA control signal.

.8 The wheel shall be ARI certified by the energy recovery wheel supplier to ARI Standard 1060 and must bear the ARI certification stamp. Private independent testing performed "in accordance with" various standards is not a substitute for ARI certification and shall not be accepted. The wheel shall be listed or recognized by UL or equivalent.

2.10 Controls

.1 Controls shall be field supplied and installed.

.2 Provide Dwyer pressure transducer for airflow measurement. Provide wiring on site.

2.11 Unit electrical

.1 Unit manufacturer shall provide wiring from each fan motor to a variable speed drive complete with NEMA 3R enclosure.

.2 Provide lights in all access sections. Lights shall be wired to an ON-OFF switch mounted on the outside of the cabinet. Interconnecting wiring between split sections shall be field supplied and installed.

.3 Provide a GFI receptacle mounted on the outside of the unit cabinet in fan sections. GFI shall be powered off the field supplied lighting power feed.

3 Execution

3.1 Examination

.1 Verification of existing conditions prior to beginning work.

.2 Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings.

.3 Verify that proper power supply is available.

3.2 Installation

.1 Install to manufacturer's instructions.

.2 Support independently of adjacent ductwork with flexible connections.

.3 Install access doors in accordance with Section 23 33 00 – Ductwork Accessories for access to coils, dampers, etc.

.4 Install condensate drain, minimum connection size, with trap and direct to nearest drain.

.5 Recovery units shall automatically shut-off from building Fire Alarm Panel. Coordinate with electrical contractor.

.6 Locate remote panels where indicated.

3.3 Manufacturer's field services

.1 Prepare and start systems to Section 20 01 00 – Mechanical General Requirements.

.2 Provide initial start-up and shut-down during first year of operation, including routine servicing and check-out.

End of section

1 General

1.1 Section includes

.1 Dedicated Outdoor Air Units (DOAS)

1.2 Related requirements

.1 Section 00 65 36 – One year extension of contract warranty period

.2 Section 20 01 00 – Mechanical General Requirements

.3 Section 20 05 00 – Common Mechanical Work Results

1.3 Reference standards

.1 ARI 270 - Sound Rating of Outdoor Unitary Equipment.

.2 ASHRAE 84-2013, Method of Testing Air-to-Air Heat/Energy Exchangers (ANSI approved).

.3 ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

.4 ASHRAE 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Section 20 01 00 – Mechanical General Requirements: Procedures for submittals.

.4 Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical

service with electrical characteristics and connection requirements, and duct connections.

.5 Product Data:

.1 Provide literature which indicates dimensions, operating weights, capacities, ratings, fan performance, gauges and finishes of materials, and electrical characteristics and connection requirements.

.2 Provide data of filter media, filter performance data, filter assembly, and filter frames.

.3 Provide fan curves with specified operating point clearly plotted.

.4 Submit sound power level data for both fan outlet and casing radiation at rated capacity.

.5 Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

.6 Section 20 01 00 – Mechanical General Requirements: Submittals for information.

.7 Submit manufacturer's installation instructions. Indicate assembly, support details, connection requirements, and include start-up instructions.

.8 Section 20 01 00 – Mechanical General Requirements: Submittals for project closeout.

.9 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

.2 ARI Compliance:

.1 Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies.

.2 Comply with ARI 270 for testing and rating sound performance.

.3 NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 Delivery, storage and protection

.1 Section 20 01 00 – Mechanical General Requirements: Transport, handle, store, and protect products.

.2 Protect units from physical damage by storing off site until 100mm high concrete pad is in place and mechanical room is ready for immediate installation of unit.

1.8 Warranty

.1 Provide the following warranties:

.1 Two (2) years starting from date of Substantial Performance.

1.9 Maintenance service

.1 Section 20 01 00 – Mechanical General Requirements: Submittals for project closeout.

.2 Provide service and maintenance of packaged air handling units for one (1) year from Date of Substantial Completion.

.3 Provide maintenance service with a two (2) month interval as maximum time period between calls. Provide twenty four (24) hour emergency service on breakdowns and malfunctions.

.4 Include maintenance items as outlined in manufacturer's operating and maintenance data, including minimum of six (6) filter replacements, minimum of one (1) fan belt replacement, and controls check-out, adjustments, and recalibration.

.5 Submit copy of service call work order or report, and include description of work performed.

1.10 Extra materials

.1 Section 20 01 00 – Mechanical General Requirements: Submittals for project closeout.

.2 Provide one (1) set of filters.

2 Products

2.1 General

.1 Comply with ASHRAE 84.

.2 The following manufacturers are approved in principle subject to meeting the specifications. Manufacturers are responsible for all co-ordination issues arising from dimensional variances between plans and site conditions: Daikin, Innovent, Ventrol, or approved alternate.

.3 Air handling units shall be ETL-Canada safety listed to conform to UL Standard 1995 and CAN/CSA Standard C22.2 No. 236. Air handling unit water cooling coil and glycol heating coil shall be certified in accordance with the forced circulation air cooling and air heating coils certification program, which is based on ARI Standard 410.

2.2 Casing

.1 Fabricate unit with 16 gauge nominal channel posts and panels secured with mechanical fasteners. All panels and access doors shall be sealed with bulb-type gasket.

.2 Panels and access doors shall be constructed as a 2-inch (50-mm) nominal thick, thermal broke double wall assembly, injected with foam insulation for an R-value of not less than R-13. The outer casing shall be constructed of G60 galvanized steel, phosphatized and painted with baked on enamel.

.3 The inner liner shall be constructed of G90 galvanized steel. Panel deflection shall not exceed L/240 at 125% of design static pressure, minimum +/- 8 in. Deflection shall be measured at the midpoint of the panel height.

.4 The casing leakage rate shall not exceed 0.5 cfm per square foot of cabinet area at 6 inches of negative static pressure or 5 inches of positive static pressure.

.5 Access doors shall be flush mounted to the cabinetry and secured with heavy-duty stainless steel hinges. The door latch handle assembly shall be provided with a full-size grip handle and roller pall for smooth operation. The assembly shall be gasketed and sealed to prevent thermal bridging. Provide inspection window for each access door.

.6 Construct drain pans from stainless steel with cross break and pitch to drain connection. Provide drain pans under cooling coil section.

.7 Provide unit with a factory installed 6 inch high full perimeter channel base rail.

2.3 Outdoor air intake section

.1 Provide outdoor air intake sections with factory mounted low leak airfoil outside air dampers of galvanized steel in galvanized frame. Dampers shall be hollow core airfoil blades, fully gasketed. Provide continuous vinyl seals between damper blades. Provide stainless steel end seals along end of dampers. Provide linkage and ABS plastic end caps.

.2 Damper leakage rate shall be less than 73 m3/h per m2 (4 cfm per ft2) leakage at 1 inch static pressure differential. Leakage rate shall be tested in accordance with AMCA Standard 500.

.3 Provide fail-safe motorized damper actuator for open/close action with end switch.

2.4 Exhaust air outlet

.1 Provide factory mounted low leak airfoil exhaust air damper of galvanized steel in galvanized frame. Dampers shall be hollow core airfoil blades, fully gasketed. Provide continuous vinyl seals between damper blades. Provide stainless steel end seals along end of dampers. Provide linkage and ABS plastic end caps.

.2 Damper leakage rate shall be less than 73 m3/h per m2 (4 cfm per ft2) leakage at 1 inch static pressure differential. . Leakage rate shall be tested in accordance with AMCA Standard 500.

.3 Provide fail-safe motorized damper actuator for open/close action with end switch.

2.5 Filters

.1 Provide outdoor air and exhaust air filter box sections located on the inlet to the energy recovery device. Filter sections shall include filter guides, hinged and latching access doors on one side, for side loading of filters.

.2 Filter media shall be UL 900 listed.

.3 For the exhaust air stream provide flat arrangement with 2 inch deep MERV 8 pleated panel filter.

.4 For the outdoor air stream provide extended surface filter box with holding frames suitable for 2 in MERV 8 pleated panel prefilter and final filter, media and blank-off sheets, extended surface cartridge media filters with MERV 13 rating. Cartridge filter media shall be 12 in deep. 4 in secondary filters will not be accepted.

.5 Provide Magnehelic filter gauges for each filter bank flush mounted into unit casing with factory mounted probes.

2.6 Fans

.1 Provide ECM, motorized impeller fan(s). Fan assembly shall include fan, fan base, and a motor and shall be dynamically balanced by the fan manufacturer.

.2 Motor control panel shall come with a low voltage terminal strip and shall include terminals for Fan ON/OFF, 0-10V signal, and fan fault.

.3 Motor control panel shall come equipped with a fused disconnect.

.4 Unit shall be provided with a ship loose motor control panel for the fan section. All motor wiring shall be field supplied and installed.

.5 Motor shall be brushless DC type with a permanent magnet rotor.

.6 Inverter shall be integral to the motor and come as an assembly from the fan manufacturer.

2.7 Coils

.1 Provide access to coils from connection side of unit for service and cleaning. Enclose coil headers and return bends fully within unit casing.

Fabricate coil connections, vents and drains to extend beyond unit casing including gromments for an airtight unit casing. Coils shall be removable through side panels and/or top panels of unit without removal and disassembly of entire section.

.2 Provide stainless steel drain pan located underneath and extending downstream of coil and intermediate drain pans.

.3 Coil performance shall be as per schedule. Coil performance data shall be certified in accordance with ARI Standard 410 where applicable.

.4 Cooling Coil Construction:

.1 Tubes: Copper.

.2 Fins: Aluminum mechanically bonded to tubes.

.3 Headers: Seamless copper with vent and drain connections.

.4 Casing: 16 gauge, stainless steel channels with 16 gauge center and end supports.

.5 Heating Coil Construction:

.1 Tubes: Copper.

.2 Fins: Aluminum mechanically bonded to tubes.

.3 Headers: Seamless copper with vent and drain connections.

.6 Water cooling and glycol heating coil shall be circuited drainable with a vent connection at the highest point and a drain connection at the lowest point. Coil headers shall be copper with steel male pipe connections.

2.8 Access

.1 Access sections shall be 14” deep. Provide access doors of galvanized steel flush mounted, with gasket, latch and handle assembly.

2.9 Energy recovery wheel

.1 Provide enthalpy wheels factory installed in units.

.2 Energy recovery wheel shall be constructed of alternate layers of corrugated and flat aluminum sheet material. Synthetic media wheels will not be accepted. All surfaces shall be coated or uniformly bound with a non-migrating absorbent specifically developed for the selective transfer of water vapor.

.3 Media shall be engineered to provide corrosion resistance and resistance against attack from laboratory chemicals present in pharmaceutical, hospital, etc. environments as well as attack from external outdoor air conditions. The rotor media shall be capable of being cleaned with low temperature steam without degrading unit performance.

.4 The desiccant material shall be a molecular sieve, and specifically a 3A molecular sieve to minimize cross contamination.

.5 The wheel frames shall consist of evenly spaced steel spokes, galvanized steel outer band and rigid center hub. Adjustable brush seals must be provided along the periphery of the rotor and between the inlet and outlet air passages to effectively prevent air leakage and cross-contamination between airflows.

.6 Cassettes shall be fabricated of heavy duty reinforced galvanized steel or welded structural box tubing. Cassettes shall have a built in adjustable purge section minimizing cross contamination of supply air. Bearings shall be inboard, zero maintenance, permanently sealed roller bearings, or alternatively, external flanged or pillow block bearings.

.7 The rotor drive system shall consist of a self-adjusting belt around the rotor perimeter driven by an AC motor with gear reduction. The variable speed drive shall be specifically designed for heat wheel applications and include: an AC inverter, soft start/stop, rotation detection w/alarm contacts, automatic self-cleaning jog cycle, and self-testing capability. The speed controller shall be capable of accepting a potentiometer, VDC, or mA control signal.

.8 The wheel shall be ARI certified by the energy recovery wheel supplier to ARI Standard 1060 and must bear the ARI certification stamp. Private independent testing performed "in accordance with" various standards is not a substitute for ARI certification and shall not be accepted. The wheel shall be listed or recognized by UL or equivalent.

2.10 Controls

.1 Controls shall be field supplied and installed.

.2 Provide Dwyer pressure transducer for airflow measurement. Provide wiring on site.

2.11 Unit electrical

.1 Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.

.2 Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.

.3 Installing contractor shall provide GFI receptacle within 25 feet of unit to satisfy National Electrical Code requirements.

.4 Provide lights in all access sections. Lights shall be wired to an ON-OFF switch mounted on the outside of the cabinet. Interconnecting wiring between split sections shall be field supplied and installed.

3 Execution

3.1 Examination

.1 Verification of existing conditions prior to beginning work.

.2 Verify that proper power supply is available.

3.2 Installation

.1 Install to manufacturer's instructions.

.2 Support independently of adjacent ductwork with flexible connections.

.3 Install access doors in accordance with Section 23 33 00 – Ductwork Accessories for access to coils, dampers, etc.

.4 Install condensate drain, minimum connection size, with trap and direct to nearest drain.

.5 Recovery units shall automatically shut-off from building Fire Alarm Panel. Coordinate with electrical contractor.

.6 Locate remote panels where indicated.

3.3 Manufacturer’s field services

.1 Prepare and start systems to Section 20 01 00 – Mechanical General Requirements.

.2 Provide initial start-up and shut-down during first year of operation, including routine servicing and check-out.

End of section

1 General

1.1 Section includes

.1 Water Source Heat Pumps

1.2 General requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 ARI 210/240 - Unitary Air Conditioning Equipment and Air-Source Heat Pump Equipment.

.2 NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

.3 UL 465 - Central Cooling Air Conditioners.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Provide catalogue data indicating rated capacity, dimensions, duct and service connections, electric nameplate data and wiring diagrams.

.4 Shop Drawings: Indicate layout of system and components.

.5 Manufacturer's Instructions: Indicate installation instructions and recommendations.

.6 Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

.7 Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 Warranty

.1 Provide five (5) year manufacturer warranty for compressors, starting from date of Substantial Performance.

2 Products

2.1 General

.1 Unit shall meet the performance detailed in the schedule. Construction and ratings shall be in accordance with latest ARI Standard 550/590, ANSI/ASHRAE 15, CSA-B52 and ASME Code.

.2 Equipment shall meet efficiency standards of ASHRAE Standard 90.1

.3 NXP machines shall be multipurpose chillers designed specifically for the simultaneous and independent production of cold and hot water in response to both cooling and heating demand signals. Units shall be configured for use in a six pipe system.

.4 All chiller manufacturers must be able to provide tested and catalogued data detailing unit performance under all specified chiller operating modes (i.e. heat recovery mode, heat pump mode, heating mode). Custom unit modifications made at the factory level, or on site, which do not form part of the standard catalogued performance data, will not be accepted.

.5 All chiller manufacturers shall meet or exceed the specified equipment Total Efficiency Ratio (TER) of 22.65 at design conditions. Ratio shall take

into consideration the total capacity produced simultaneously (through heating and cooling) and the total electrical power input to the unit. TER shall be calculated as follows: TER = (Heating Capacity + Cooling Capacity) / Electrical Power Input

2.2 Cabinet

.1 The unit shall be completely factory assembled on a rugged steel base and shall be shipped with a full operating charge of R410A refrigerant.

.2 As standard, chiller components shall be housed in an acoustically treated enclosure designed specifically to reduce radiated noise transmission by a minimum of 6 db(A). Enclosure panels shall be painted with a baked on polyester powder to provide an aesthetically pleasing finished product.

.3 Spring vibration isolators shall be factory supplied for field installation.

2.3 Compressors

.1 The compressors shall be sealed hermetic scroll type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, two-pole, with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads.

2.4 Evaporator and condenser

.1 Evaporator and condensers shall be direct expansion type with stainless steel plates brazed together. Evaporator shall be insulated with closed cell polyurethane insulation.

.2 All units shall be provided with three plate heat exchangers, two dedicated entirely to the production of cold and hot water for the system, the other shall be dedicated to the condenser / geothermal loop. Chillers manufactured with only two heat exchangers and cross-over valves will not be accepted.

.3 Flow switches shall be supplied loose for field installation by others. Installing contractor shall wire flow switch back to main unit control panel.

2.5 Refrigerant circuit

.1 All units shall feature a minimum of two independent refrigerant circuits coupled to a common hydraulic circuit for increased reliability. Unit shall be capable of operating at reduced load with one refrigerant circuit shut down.

.2 Each refrigerant circuit shall include a liquid line shutoff valve, replaceable core or sealed filter-drier, sight glass with moisture indicator, liquid line solenoid valve, thermal expansion valve, and insulated suction line.

2.6 Controls

.1 The control panel shall contain a microprocessor controller providing operating and equipment protection controls, plus motor starting equipment. Controller shall be factory wired, operationally tested, and ready for operation. Standard components shall include a control transformer with primary and secondary fusing, microprocessor transformers with integral fusing, compressor contactors, circuit breakers, single-point wiring arrangement and switches for each circuit pump down and unit control power.

.2 The control system shall stage the compressors based on the leaving water temperature.

.3 Heat pump shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off.

.4 Equipment protection devices include motor protection, high pressure, loss of refrigerant, loss of water flow, freeze protection, and low refrigerant pressure. Controls shall include auto/stop switch, chilled water set point adjustment, anti-recycle timer, and digital display with water temperature and set point, operating temperatures and pressures, and diagnostic messages.

.5 The keypad/display shall provide access to all vital equipment data. Data shall include full description of current unit status, setpoint parameters, and alarms. Data shall be displayed in clear, precise English text. Programmable security password protection shall be provided.

.6 Control system shall monitor all system temperatures, pressures and safeties, and shall automatically shut down a refrigerant circuit or entire

unit should a fault occur. All fault conditions shall be automatically time and date stamped, retained in memory and shall be available for display.

.7 The DDC controller shall be equipped with a timeclock to allow the user to program a daily or weekly schedule. The control system shall have auto-restart after power failure and NOT require battery back-up or auxiliary power supply for maintaining program memory. The microprocessor shall have a lithium battery timeclock to automatically ensure correct time of day input after power failure. Once power is restored, the controller shall check for any other faults and if none are present, shall permit normal unit operation.

.8 Microprocessor shall accept a 4-20 mA DC for resetting chilled water temperature.

.9 The microprocessor shall incorporate two short cycle time functions: start to start; and stop to start. These shall be specially programmed to provide the least amount of time off line while providing the maximum compressor motor protection.

.10 During part load operation, the controller shall unload alternately between refrigeration circuits to maximize efficiency. On unit start-up, the microprocessor shall limit the rate at which chilled water loop temperature is pulled down. The pulldown rate shall be adjustable.

.11 Controller shall provide output contact closure for control of chilled water and condenser water pump.

.12 The chiller shall be factory installed with a microprocessor based DDC controller capable of communications with any Building Automation System supporting BACnet, Modbus and LONMark communications protocol. The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.

2.7 Electrical

.1 Field power connection, control interlock terminals and unit control system shall be centrally located. Panel access door shall key lock to prevent unauthorized access. Dead front panel shall protect service personnel against accidental contact with line voltage components.

.2 Chiller shall be supplied with factory installed non fused disconnect.

2.8 Refrigerant alarm panels

.1 The refrigerant monitoring system shall be comprised of three main components: one main control panel, a minimum of one remote alarm panel, and a minimum of one remote alarm sensor. The main panel shall be located inside the machinery room near the main entrance. The remote panel(s) shall be located outside of each entranceway to the machinery room.

.2 Alarm panels shall be equipped with a visual flashing amber beacon, audible buzzer and a user interface touch screen display. The display on the main panel shall have a full color 6 inch screen. Remote panels shall be complete with a monochrome 4 inch display. Keypad menu entry touch keys shall also be provided for quick access to panel configuration settings and also to silence audible alarms.

.3 The following menus shall be accessible via the touch screen displays:

.1 System configuration

.2 Diagnostic information

.3 Alarm setup

.4 Sensor setup

.5 System test

.4 The monitoring panel shall allow for two alarm settings. A low level alarm shall warn (flashing yellow screen) that refrigerant gas has been detected but the room is still safe. The screen shall display the gas ppm concentration. A high level alarm shall automatically activate audio / visual alarms, and initiate mechanical ventilation. Three high level alarm relays shall be provided for customer interlocks; boiler alarm, fan relay and chiller relay.

.5 All panels shall also include Ventilation ON and Chiller OFF switches. Switches shall be password protected on all remote panels.

.6 The refrigerant sensor shall use non-dispersive infrared technology to selectively target the refrigerant gas. Sensor shall continuously monitor the air and send a signal proportional to the refrigerant ppm concentration,

back to the main control panel. Sensor shall have a life expectancy of 10 years.

.7 Control panel relay outputs shall be configurable for Failsafe or Non-Failsafe modes of operation.

.8 The master panel shall be powered from a 120 volt circuit. The remote panel and refrigerant sensor(s) shall be powered through this master panel.

.9 Provide R-410a refrigerant sensor(s) mounted in close proximity to the chillers and wired to the master panel. The refrigerant sensor shall be calibrated to detect refrigerant levels equal to or less than the TLV-TWA for the refrigerant used. The alarm system shall be activated when the refrigerant concentration in the mechanical room equals the TLV-TWA for the refrigerant used.

.10 The Refrigerant monitoring system shall meet the requirements of CSA - B52 Mechanical Refrigeration Safety Code (latest version).

.11 Chiller manufacturer shall provide all necessary interconnecting wiring diagrams for installation purposes.

.12 Provide a calibration kit. Include one cylinder of calibrated refrigerant gas for each refrigerant used in this installation.

2.9 Startup service and warranty

.1 Manufacturer shall furnish a factory trained service technician to perform the unit startup. Manufacturer shall provide instruction of the owner's personnel on the operation and maintenance of the unit. The warranty period shall commence at the date of initial startup and shall continue for a period of two (2) years, starting from date of Substantial Performance. Manufacturer's warranty shall include all parts and labour to install parts.

.2 Manufacturer shall include two additional site visits. The first to be scheduled around the 6 month mark after the initial startup to accommodate seasonal changes to the system and a second visit as required to address any operational issues.

3 Execution

3.1 Installation

.1 Install units on a flat surface level within 1/8 inch and of sufficient strength to support concentrated loading.

.2 Provide components furnished as per manufacturer's literature.

.3 Provide all water piping so unit and water circuits are serviceable, without having to dismantle excessive lengths of pipe.

.4 Provide valves in water piping upstream and downstream of the evaporator and condenser water connections for isolating the shells for maintenance and to balance and trim the system.

.5 Provide strainers ahead of all pumps and automatic modulating valves.

.6 Provide pressure relief piping from relief valve to outside in accordance with manufacturer's instructions and CSA-B52.

.7 Provide certified wiring schematics to the electrical division for the chiller, associated equipment and controls.

.8 Provide all necessary control wiring as recommended by the manufacturer

.9 Install loop water controller where shown on drawings and according to manufacturer’s instructions.

.10 Install all control wiring required to provide a complete and operating system between loop water controller and water cooled air conditioning units and to all accessories as per manufacturer's wiring diagrams.

.11 Coordinate with Electrical Division all power wiring to heat pumps, loop water controller and accessories.

.12 Furnish the services of a trained representative of the equipment manufacturer to supervise the installation, wiring, set up and testing of the loop water controller.

End of section

1 General

1.1 Section includes

.1 Fan coil units

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Product Data: Provide typical catalogue of information including arrangements.

.4 Shop Drawings:

.1 Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.

.2 Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.

.3 Indicate mechanical and electrical service locations and requirements.

1.4 Closeout Submittals

.1 Provide Closeout submittals in accordance with Section 01 78 00 – Closeout Submittals, and provide 11x17 sized record drawing of the fan coil installation plan overlain on the reflected ceiling plan. This drawing

will illustrate the location of the ceiling panels that can be removed for easiest access to fan coil unit for servicing.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

1.6 Regulatory requirements

.1 Products requiring electrical connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

2 Products

2.1 Fan Coil FC-1 to FC-19

.1 Fan coil type and arrangement

.1 The fan coil shall be furnished as a draw-through cooling coil with a heating coil in preheat/reheat position.

.2 Manufacturer

.1 Daikin; or

.2 Other approved alternate manufacturers, subject to shop drawing review.

.3 General construction

.1 The units shall include a chassis, coil(s), fan deck with blower(s)/blower housing and motor(s). Steel parts exposed to moisture shall be galvanized and insulated to prevent condensation. The complete fan assembly shall be easily removable for service and maintenance. A quick-connect motor electric plug shall be provided.

.2 Hideaway Unit shall be supplied with return plenum complete with filter frame and filter. The plenum shall be fabricated of 18 gauge galvanized steel. The inside plenum surface shall be insulated with 1/2" matt-faced fiberglass insulation. Plenum insulation shall meet

minimum K value of 0.24 (BTU-in)/(hr-ft2-F) and rated for maximum air velocity of 5000 fpm. Fiberglass insulation conforms to:

.1 ASTM C1071 (including C665)

.2 UL 181 for erosion

.3 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A

.4 Supply fan

.1 Supply fans shall be a DWDI forward-curved type. Fan assemblies including fan, motor and sheaves shall be dynamically balanced by the manufacturer on all three planes at all bearing supports. Manufacturer must ensure maximum fan RPM is below the first critical speed.

.2 The complete fan assembly, including motor and main drain pan shall be easily removable.

.3 Units shall be certified in accordance with the Room Fan Coil Unit certification program that is based on ARI Standard 440.

.4 An ECM blower motor shall be provided on all units. Factory motor wiring shall be set for optimum fan performance. The unit shall be shipped at one fixed setting. The ECM motor shall utilize a permanent magnet rotor, which is connected to the shaft through resilient rings to absorb high frequency torque ripple. ECM motor shall be programmed for constant CFM or constant torque.

.5 Electrical

.1 Supply fans shall be run-tested in the assembled unit and permanently lubricated. All motors shall have integral thermal overload protection with a maximum ambient operating temperature of 104°F. Motors shall be capable of starting at 78 percent of rated voltage and operating at 90 percent of rated voltage on all speed settings. Motors shall operate up to 10 percent overvoltage.

.2 Motor wires shall include a quick-disconnect motor plug.

.6 Cooling Coils

.1 Cooling performance shall be as specified on the unit schedule.

.2 Water coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins. Coil casing shall be constructed of galvanized steel.

.3 Water coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections shall be provided at the highest point to ensure proper venting. Drain connections shall be provided at the lowest point.

.4 All steel parts exposed to moisture shall be galvanized.

.5 Unit shall include a noncorrosive, galvanized main drain pan, positively sloped in every plane and insulated with closed-cell insulation. The drain pan shall be designed to ensure no pooling of condensate water per ASHRAE 62.2.

.7 Water Heating Coil

.1 Heating performance shall be as specified on the unit schedule.

.2 Coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

.3 Coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection,

external to the cabinet. Vent connections shall be provided at the highest point to ensure proper venting. Drain connections shall be provided at the lowest point.

.8 Valve packages

.1 Fan coil units shall be provided with factory-installed valve / piping package(s)available for the primary and secondary coils. All piping packages shall be factory assembled and tested at 400 psig (2760 kPa) and re-tested for leak when factory soldered to the coil(s) at 300 psig (2069 kPa). Maximum Working Pressure of the piping package shall be 300 psig (2069 kPa).

.2 The valve package shall be designed so that any condensation is directed into the secondary drain pan. With the secondary drain pan provided, insulation of the piping package is not required.

.3 The valve package shall be provided with:

.1 Interconnecting copper piping and shut-off ball valves.

.2 Connecting supply and return lines to the unit. Four-pipe packages shall include a venting valve for the preheat or reheat coil.

.3 A manual circuit setter in the supply water pipe. The circuit setter acts as both a flow-setting device and a shut-off valve. It allows water flow through the fan coil to be set quickly and accurately. The valve shall have a memory stop so that the correct setting can be found quickly.

.4 P/T ports to measure the temperature or pressure drop across the valve. This pressure drop can be compared to factory-supplied curves that relate the pressure drop to a specific flow rate.

.5 Unions at the coil connections.

.6 Isolating ball valve on the supply side.

.7 Control valves in the supply water pipe.

.8 Two-Way Modulating Valves that modulate the water flow through the coil in response to a signal from the thermostat or controller. All modulating valves shall be three-wire floating point equal percentage valves. The modulating

valves shall be factory mounted in the supply water pipe upstream of the coil.

.9 Filters

.1 Filters shall be 1” (25 mm) throwaway. They shall be concealed from sight and easily removable.

.10 Controls

.1 Unit shall be supplied with a DDC interface board.

.2 DDC Interface board shall have three 24-volt relays with line-voltage contactors to operate the fan motor speeds.

.3 DDC interface board shall have terminal connections for interfacing to:

.1 Wall-Mounted Thermostat

.2 Low-voltage, on-off valve actuators.

.3 A return air sensor.

.4 Condensate overflow switch.

.5 Room occupancy sensor.

.4 Unit shall have high/medium/low air flow connections for field wiring by BAS contractor via dry contact terminals.

2.2 Fan Coil FC-20

.1 Fan coil type and arrangement

.1 A. The fan coil unit shall be furnished as a draw-through style hydronic unit.

.2 A Secondary preheat coil located downstream of the primary coil shall be factory furnished. Entering water conditions are not to exceed 200°F.

.2 Manufacturer

.1 Daikin PreciseLine; or

.2 Other approved alternate manufacturers, subject to shop drawing review.

.3 General construction

.1 The fan coil unit shall include a blower, fan housing, coil, and drain-pan enclosed within and mounted to a rigid cabinet. Steel parts exposed to moisture shall be galvanized and insulated to prevent condensation. The complete fan assembly shall be wired via quick connect electrical contacts and easily removable for service and maintenance.

.2 Cabinet shall be supplied with 1-inch, double-wall panels. The cabinet is to be thermally isolated through injected foam insulation inside each cabinet. Single wall cabinets with fiberglass insulation exposed in the airstream are not acceptable. Frame channels which allow heat conductance between the inside and outside of the cabinet are not acceptable. Base rails used for unit mounting/hanging are acceptable. Panel shall have a minimum thermal insulation of R6. Foam injected insulation conforms to:

.1 ASTM C1071 (including C665)

.2 UL 181 for erosion

.3 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A

.4 Supply fan

.1 Supply fans shall be a DWDI forward-curved type. Fan assemblies including fan, motor and sheaves shall be dynamically balanced by the manufacturer on all three planes at all bearing supports. Manufacturer must ensure maximum fan RPM is below the first critical speed.

.2 The complete fan assembly, including motor and main drain pan shall be easily removable.

.3 Fan motor(s) assembly shall be direct-drive style and not include belts, pulleys, or sheaves.

.4 Fan motor(s) shall be of Direct Current Brushless type or minimum motor efficiency of 85 percent when rated in accordance of NEMA Standard MG 1-2016 at full load conditions.

.5 Manufacturer’s supply fan motor must have means to adjust motor speed for field balancing.

.6 Units shall be certified in accordance with the Central Station Air Handler certification program that is based on AHRI Standard 430.

.5 Electrical

.1 Supply fans shall be driven by Electrically Commutated motors that are run-tested in the assembled unit and permanently lubricated. All motors shall have integral thermal overload protection with a maximum ambient operating temperature of 55°C. Motors shall be capable operating at 90 percent of rated voltage on all speed settings. Motors shall operate up to 10 percent overvoltage.

.2 Motor wires shall include a quick-disconnect motor plug.

.3 All controls equipment including ECM control module, low voltage transformers, safety switches, disconnects, fusing, and terminal strips must be located inside the main unit cabinet.

.6 Cooling Coils

.1 Cooling performance shall be as specified on the unit schedule.

.2 Water coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins. Coil casing shall be constructed of galvanized steel.

.3 Water coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections shall be provided at the highest point to ensure proper venting. Drain connections shall be provided at the lowest point.

.4 All steel parts exposed to moisture shall be galvanized.

.5 Unit shall include a galvanized steel primary and secondary drain pan. The primary drain pan to be positively sloped in every plane.

Primary and secondary drain pans to be insulated with anti-microbial closed-cell insulation. The drain pan shall be designed to ensure no pooling of condensate water per ASHRAE 62.2.

.6 Coils shall have stub-outs off of the headers extending through the unit paneling.

.7 Water Heating Coil

.1 Heating performance shall be as specified on the unit schedule.

.2 Coil fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Seamless copper tubes shall be mechanically expanded into the fins to provide a continuous primary-to-secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

.3 Coils shall be provided with headers of seamless copper tubing with intruded tube holes to permit expansion and contraction without creating undue stress or strain. Coil connections shall be copper sweat connections with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain connections shall be furnished on the coil connection, external to the cabinet. Vent connections shall be provided at the highest point to ensure proper venting. Drain connections shall be provided at the lowest point.

.8 Valve packages

.1 Fan coil units shall be provided with factory-installed valve / piping package(s)available for the primary and secondary coils. All piping packages shall be factory assembled and tested at 400 psig (2760 kPa) and re-tested for leak when factory soldered to the coil(s) at 300 psig (2069 kPa). Maximum Working Pressure of the piping package shall be 300 psig (2069 kPa).

.2 The valve package shall be designed so that any condensation is directed into the secondary drain pan. With the secondary drain pan provided, insulation of the piping package is not required.

.3 The valve package shall be provided with:

.1 Interconnecting copper piping and shut-off ball valves.

.2 Connecting supply and return lines to the unit. Four-pipe packages shall include a venting valve for the preheat or reheat coil.

.3 An automatic circuit setter. The circuit setter includes a cartridge within the valve body that is sized to allow a specific flow rate through the coil. This valve sets flow through the coil without any action required by a system piping balancer.

.4 P/T ports to measure the temperature or pressure drop across the valve. This pressure drop can be compared to factory-supplied curves that relate the pressure drop to a specific flow rate.

.5 Unions on the valve package that allow the coil and valve package to be separated and removed from the unit.

.6 A 20 mesh strainer on the supply side that is easily removed for cleaning, with a blow-off valve. The strainer shall have a pressure rating of up to 400 psig (2,700 kPa).

.7 Isolating ball valve on the supply side.

.8 Control valves in the supply water pipe.

.9 Two-Way Modulating Valves that modulate the water flow through the coil in response to a signal from the thermostat or controller. All modulating valves shall be three-wire floating point equal percentage valves. The modulating valves shall be factory mounted in the supply water pipe upstream of the coil.

.10 The valve package shall be furnished with proportional modulating actuators. The furnished actuators are to be controlled via 0-10VDC control signal

.9 Filters

.1 Filters shall be of disposable type with a minimum arrestance of 75%-80% and rating of MERV 4. Filters shall be easily accessible via a door or panel located on the bottom of the unit.

.10 Discharge Plenum

.1 A factory installed discharge plenum is to be furnished attached to the main unit. This component must be constructed of a similar cabinet paneling to the main unit.

.2 Sound-absorbing material shall be affixed to the internal walls of the discharge plenum.

.11 Controls

.1 Unit shall be supplied with a digital controls ready interface. This interface is to be located inside the control box internal to the main unit. This interface shall include a 24VAC transformer and terminal blocks for connections to fan motor control, sensor control, safety switches, valve actuators.

.2 DDC interface board shall have terminal connections interfacing to:

.1 Wall-Mounted Thermostat

.2 Low-voltage, on-off valve actuators.

.3 A return air sensor.

.4 Condensate overflow switch.

.3 Unit shall be furnished with a disconnect switch. The disconnect switch shall be operable from the outside of the cabinet to reduce hazards during field service and commissioning.

3 Execution

3.1 Installation

.1 Install drain line fabricated from Type L copper tube. Slope drain away from unit and insulate.

.2 Install isolation ball valves in coil piping in accordance with valve manufacturer's instructions. Be sure valves are in proper operating position and are easily accessible for adjustment.

.3 Install unit on spring vibration isolators. Refer to Section 20 05 48 – Vibration and Noise Control.

.4 Supports, piping, conduit, etc., shall allow for proper access to access panels, filters, etc. Demonstrate at time of mock-up review.

.5 Contractor is to ensure that the cabinet or components of the fan coil unit do not make rigid contact with any architectural, structural, electrical, or mechanical components of the building.

.6 Contractor to inform Consultant and Owner of plans for final filter change one (1) week prior to execution. Consultant and Owner may choose to use this opportunity to perform fan coil portion of final inspection.

.7 Install isolation valves with Pete's Plugs on heating and cooling coil supply.

.8 Install unit horizontal.

.9 Install acoustic insulated sound trap on inlet.

.10 Allow horizontal access the width of the unit for filter removal, coil removal and valve servicing.

.11 Provide drain from below shutoff valve and control valve assemblies.

.12 Install flexible duct connection on discharge. Refer to Section 23 33 00 – Ductwork Accessories.

.13 Insulate all chilled water supply, valves, drain valves, pipes, drains, traps, braided connectors and similar components with rubber insulation. Refer to Section 23 21 14 – Hydronic Equipment and Specialties.

.14 Install hose kit on chilled water/hot water supplies to coils.

.15 BAS contractor shall provide the wiring to dry contact terminals of fan coil units FC-1 to FC-19 and program the units to adjust the fan speed based on occupancy/time-of-day schedule. Refer to drawings and Sequence of Operation for list of fan coil units and the rooms where thermostats have integrated occupancy sensors.

3.2 Cleaning

.1 After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

.2 Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials provided by manufacturer (VOC content not to exceed 250 g/L).

.3 Install new filters.

End of section

1 General

1.1 Section includes

.1 Unit heaters

.2 Force Flow Heaters

.3 Convector Heaters

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Provide typical catalogue of information including arrangements.

.4 Shop Drawings:

.1 Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.

.2 Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.

.3 Indicate mechanical and electrical service locations and requirements.

1.4 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

1.5 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Manufacturers

.1 Sigma or approved alternate.

.2 Other acceptable manufacturers, subject to shop drawing review:

.1 Rittling;

.2 Modine;

.3 Rosemex;

.4 Stirling; or

.5 Approved alternate.

2.3 Unit Heaters

.1 Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.

.2 Casing: 1.2 mm steel with threaded pipe connections for hanger rods.

.3 Finish: Factory applied baked primer coat.

.4 Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.

.5 Air Outlet: Adjustable pattern diffuser on projection models and two way louvres on horizontal throw models.

.6 Motor: permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models.

.7 Control: Local multi-speed disconnect switch. Provide remote thermostat as shown on drawings.

.8 Capacity: As scheduled.

2.4 Force Flow Heaters

.1 Heating coils shall be manufactured from 1/2 in outside diameter seamless copper tubes expanded within corrugated aluminum fins. designed for working pressures up to 1034 kPa (150 psi).

.2 Enclosure. The enclosure shall be constructed of 16ga. heavy duty corrosion resistant 16 Ga steel. The removable front panel shall be fastened securely to the cabinet and not to the wall. Provide complete front and back convector cabinet.

.3 Fan: Twin centrifugal double-inlet double-width fans shall be mounted onto double-shafted motors for quiet operation and optimum airflow distribution across the coil and through the unit. All fan wheels and fan housings shall be corrosion resistant.

.4 Filters: Wire framed polyester media filters.

.5 Motor: Permanent split capacitor type motors with self aligning sleeve bearings for durable motor life, low operating cost and reduced noise levels, complete with a motor controller.

.6 Control: Provide Motor Starter with Overload protection. Provide built-in thermostat or remote thermostat as shown on drawings.

.7 Capacity: As scheduled.

2.5 Convector Heaters

.1 Enclosure. The enclosure shall be constructed of 16ga. galvanized steel prime painted with a flat top. Cabinet fronts and lines constructed from heavy duty corrosion resistant 16 ga. for the complete convector cabinet.

The removable front panel shall be fastened securely to the cabinet and not to the wall. Provide complete front and back convector cabinet.

.2 Heating coils shall be manufactured from 1/2 in outside diameter seamless copper tubes which are expanded into collared aluminium fins. Coils shall be designed for working pressures up to 1034 kPa (150 psi) and have 3/4 in NPT connections as standard.

.3 Refer to the schedule on the drawings.

3 Execution

3.1 Installation

.1 Install to manufacturer's instructions.

.2 Install equipment exposed to finished areas after walls and ceiling are finished and painted. Avoid damage.

.3 Protection: Provide finished cabinet units with protective covers during balance of construction.

.4 Unit Heaters: Hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

.5 Hydronic Units: Provide with shut-off valve on supply and lock shield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing. For force flow heaters, fan coil units, and unit heaters, provide float operated automatic air vents with stop valve.

.6 Install electric heating equipment including devices provided by manufacturer but not factory mounted. Provide copy of manufacturer's wiring diagram submittal. Install electrical wiring to manufacturer's submittals and Division 26.

3.2 Cleaning

.1 After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

.2 Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials provided by manufacturer.

.3 Install new filters.

End of section

1 General

1.1 Section includes

.1 Crosslinked polyethylene tubing and fittings

.2 Distribution manifolds

.3 Manifold cabinets

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials

.2 ASTM F876, Standard Specification for Crosslinked Polyethylene (PEX) Tubing

.3 ASTM F877, Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems

.4 ASTM F2080, Standard Specification for Cold-Expansion Fittings With Metal Compression-Sleeves for Crosslinked Polyethylene (PEX) Pipe

.5 CSA B137.5, Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications

.6 CSA B214, Installation Code for Hydronic Heating Systems

.7 DIN 4726, Plastic Piping Used in Warm Water Floor Heating (Warmwasser-Fußbodenheizungen und Heizkörperanbindungen - Rohrleitungen aus Kunststoffen

.8 ISO 9001, Quality Management Systems – Requirements

.9 CAN/ULC S102.2, Surface Burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials

.10 PPI TR-3, Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe

1.4 Definitions

.1 Crosslinked polyethylene, or PEX is a modified polyethylene material, typically high-density polyethylene (HDPE), which has undergone a change in the molecular structure using a chemical or a physical process whereby the polymer chains are permanently linked to each other. This crosslinking of the polymer chains results in improved performance properties such as elevated temperature strength, chemical resistance, environmental stress crack resistance (ESCR), resistance to slow crack growth (SCG), toughness, and abrasion resistance. Crosslinking also makes PEX a “semi-thermoset” polymer, providing excellent long-term stability

1.5 Quality assurance

.1 Pipe shall be manufactured in a facility whose quality management system is ISO 9001 certified.

.2 Crosslinked polyethylene (PEXa) pipe shall conform and be certified to ASTM F876 and CSA B137.5, and shall have the PPI TR-3 listing. Pipes with an oxygen diffusion barrier shall conform to the requirements for oxygen permeability DIN 4726.

1.6 Qualifications

.1 Manufacturer: Must be a company specializing in the Work of this Section with a minimum of ten (10) years documented experience.

.2 Installation shall be performed by qualified installers trained by the manufacturer in the procedures required for the radiant heating and/or cooling systems and appropriately licensed for the jurisdiction where the installation will take place.

1.7 Delivery, storage and handling

.1 Deliver and store piping and equipment in shipping containers with labeling in place.

.1 Pipe shall be kept in original packaging until required for installation.

.2 Store piping and equipment in a safe place, dry, enclosed, under cover, in a well-ventilated area.

.1 Do not expose pipe to ultraviolet light beyond exposure limits recommended by manufacturer.

.2 Protect piping and manifolds from entry of contaminating materials. Install suitable plugs in open pipe ends until installation.

.3 Where possible, connect pipes to assembled manifolds to eliminate possibility of contaminants and cross-connections.

.4 Piping shall not be dragged across the ground or other surfaces, and shall be stored on a flat surface with no sharp edges.

.3 Protect materials from damage by other trades.

.4 Pipe shall be protected from oil, grease, paint, direct sunlight and other elements as recommended by manufacturer.

1.8 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Submit manufacturer's Technical Manual, submittal forms, catalog cuts, brochures, specifications, and installation instructions. Submit data in sufficient detail to indicate compliance with the contract documents.

.1 Submit manufacturer's instructions for installation.

.2 Submit data for equipment, fittings, fasteners and associated items necessary for the installation of the piping and manifolds.

.4 Submit computer-generated system design indicating pipe sizing, spacing, flow rates and temperatures. Design calculations shall be performed on pipe manufacturer's software or equivalent.

.5 Drawings: Provide plans drawn to scale for all installation areas.

.1 Indicate dimensions, descriptions of materials, general construction, component connections, anchorage methods and installation procedures.

.2 Indicate design, schematic layout of system, including equipment, critical dimensions and piping/slab penetration details as well as details for protecting exposed PEX piping.

.6 Certification

.1 Submit third-party certification results for the piping systems from an accredited testing laboratory.

.2 The design shall be approved by a professional appropriately licensed in the jurisdiction where the installation will take place, as being complete and accurate.

.3 Fittings shall be third-party certified to applicable referenced standards with independent listings from NSF and/or CSA, as applicable.

.7 Copy of the certificate indicating that the installer is certified in the installation of the manufacturer's products.

.8 Maintenance Instructions: Submit product instructions for any maintenance required or recommended by manufacturer.

.9 Final "As-Built" loop layout drawing(s).

1.9 Warranty

.1 Provide a twenty five (25) year manufacturer standard written warranty starting from date of Substantial Performance for the crosslinked polyethylene pipe.

.2 Provide a five (5) year non-prorated warranty starting from date of Substantial Performance for manifolds and fittings.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Manufacturer: Rehau Industries Inc., products indicated or equivalent by:

.1 Watts Radiant;

.2 Uponor;

.3 Heatlink; or

.4 Approved alternate.

2.3 Tubing

.1 All radiant heating and/or cooling pipe shall be high-density crosslinked polyethylene manufactured using the high-pressure peroxide method of crosslinking (PEXa). Pipe shall conform to ASTM F876 and CSA B137.5.

.2 Pipe shall be rated for 690 kPa (100 psi) gauge pressure at 82 °C (180 °F) temperature), and 550 kPa (80 psi) gauge pressure at 93 °C (200 °F) temperature.

.3 When required, pipe shall have a co-extruded oxygen diffusion barrier capable of limiting oxygen diffusion through the pipe to less than 0.32 mg/(m^2*d) @ 40 °C (104 °F) temperature, in accordance with DIN 4726.

.4 Bend Radius

.1 The minimum bend radius for cold bending of the pipe shall be not less than five (5) times the outside diameter.

.2 Bends with a radius less than this shall require the use of a bending template as supplied by the pipe manufacturer, and/or hot air.

.5 Compliant to the following standards:

.1 ANSI/UL 263 through certification listings with Underwriters Laboratories, Inc. (UL).

.2 UL Design No. L588- one (1) hour wood frame floor/ceiling assemblies

.3 UL Design No. K917 – two (2) hour concrete floor/ceiling assemblies

.4 UL Design No. U383 – one (1) hour wood stud/gypsum wallboard wall assemblies

.5 UL Design No. V461 – one (1) hour steel stud/gypsum wallboard wall assemblies

.6 Pipe to have a Flame Spread Index and a Smoke Developed Index listing to ASTM E84 (in U.S.) or CAN/ULC S102.2 (in Canada). This listing may require the pipe to be installed in a rated insulation material or an approved steel support channel.

2.4 Fittings

.1 Fittings shall be third-party certified to applicable standards ASTM F877, ASTM F2080 and CSA B137.5, with independent listings from NSF and/or CSA as applicable.

.2 Compression nut manifold fittings shall be manufactured of brass with a barbed insert and a split compression ring.

.3 Compression-sleeve fittings shall be manufactured of brass and shall be approved by the piping manufacturer to be part of a proven cataloged system.

.4 Fittings embedded within the thermal mass or encased behind walls or ceilings shall be cold-expansion compression-sleeve fittings certified to ASTM F2080. Where required by the manufacturer, fittings shall be protected from external environmental conditions.

2.5 Manifolds

.1 Material: Distribution manifolds shall be manufactured of brass, copper or stainless steel and be supplied by the piping manufacturer as a proven cataloged part of the manufacturer's system.

.2 Brass manifolds shall be produced from extruded brass round pipe with tapped holes for connections, and be pre-assembled by the manufacturer. 100 % of manifolds used shall have been air tested by the manufacturer with no indication of leaks.

.3 Balancing Manifolds

.1 Where required by design, brass balancing manifolds shall be equipped with integral visual flow gauges, circuit balancing and flow control valves, isolation valves with integral thermometer housings, and air vent/fill ports.

.2 Each circuit valve shall be supplied with a manual actuating handle for filling/purging operation.

.4 Copper Manifolds

.1 Copper manifolds shall be manufactured from Type L copper.

.2 Copper and/or brass outlets shall be high-temperature brazed (lead-free) into headers.

.3 Outlets in copper headers shall be made using the T-drill process according to ASTM F2014

2.6 Manifold cabinets

.1 Provide either surface mounted or recessed manifold cabinets, as indicated on the drawings, of sufficient size to allow sufficient space for pump, mixing valve, isolation valves, circuit setting valves, control wiring and circuit zone valves to be installed within the cabinet. Minimum size of cabinets to be 600 mm x 695 mm x 110 mm (23 5/8 in. x 27 ⅜ in. x 4 5/16 in.). Piping and components to be installed in cabinets in the factory. Coordinate control and power requirements with Divisions 25 and 26 respectively.

2.7 Controls

.1 Provide manufacture supplied wall mounted controller with LCD display and interface to BAS. Controller shall show floor temperature and room setpoint.

.2 Provide manufacturer supplied in floor temperature sensor (multiple if required by manufacturer for zoning or size of zone).

3 Execution

3.1 Examination

.1 Examine areas and conditions under which work of this Section shall be performed. Correct conditions detrimental to timely and proper completion of Work. Do not proceed until unsatisfactory conditions are corrected.

.2 Beginning of installation means acceptance of existing conditions.

3.2 Preparation

.1 Coordinate with related trades and manufacturer's recommendations with regard to installation in conjunction with:

.1 Reinforcing wire mesh or rebar.

.2 Preparation of space for manifold installation.

.2 Prepare the installation site as appropriate:

.1 For Concrete Slab-on-Grade: Sub-grade should be compacted, flat and smooth to prevent damage to pipe or insulation. Approved vapor barrier material should be installed. Approved thermal insulation, according to the design, shall be installed. Reinforcing wire mesh, if required by structural design, must be flat and level, with all sharp ends pointing down. Finished grade of the thermal mass must be a minimum of 51 mm (2 in.) above the top of PEX heating and/or cooling pipes.

.2 For Non-Structural Over pour on Sub-floor: Sub-floor must be structurally sound, clean and free from all construction debris which could potentially damage the pipe. Replace any areas that appear weak. To facilitate installation of pipe, remove all unnecessary stud wall baseplates in doorways and other areas. Treat any wood sub-floors with a sealant in accordance with the specifications set forth by the screed installation section, or use pressure-treated wood, as per local code requirements. Finished grade of the thermal mass over pour must be a minimum of 19 mm (¾ in.) above the top of PEX heating and/or cooling pipes.

.3 For Structural Concrete Sub-floor: Sub-floor must be clean and free from all construction debris which could potentially damage the pipe. Finished grade of the concrete thermal mass must be a minimum of 51 mm (2 in.) above the top of PEX heating and/or cooling pipes.

.3 Preparation of wall cavity for manifold installation: See drawings to determine the width of the wall cabinet (if required) and required wall opening dimensions. Mount the manifold cabinet allowing space for the screed to fill up the front of the pipe opening. If a cabinet is not used, prepare a suitable cavity for the manifold, with a secure mounting plate

that will secure the manifold at least 750 mm (30 in.) above floor level. Manifold must be installed in an area that will allow easy access for supply/return piping as well as future access maintenance.

3.3 Installation

.1 Install in accordance with manufacturer's published installation manual and/or published guidelines and final drawings.

.2 The bottom surfaces of floor structures incorporating radiant heating shall be insulated with a rigid foam board insulation under slab and around edges with minimum of R-3.5. Manufacturer shall ensure compression rating is suitable for application.

.3 Mount manifolds in the locations previously prepared or in previously installed cabinets, if used. Manifolds shall be mounted as level as possible.

.4 Route piping in an orderly manner, according to layout and spacing shown in final drawings. All installation notes shown on the drawings shall be followed.

.5 At connections and fittings, use a plastic pipe cutter to ensure square and clean cuts, and join pipes immediately or cap ends of pipe to seal from contaminants. No fittings shall be permitted within the thermal mass

.6 Pipe shall be dispensed using a suitable uncoiling device. Remove twists prior to securing pipe. Pipe shall lie flat on an even plane. Finished grade of a structural slab shall be a minimum of 51 mm (2 in.) above the top of PEX heating and/or cooling pipes. Fasten piping at no more than 900 mm (36 in.) intervals, being careful not to twist the pipe. In non-structural concrete slabs, the finished grade of the thermal mass shall be a minimum of 19 mm (¾ in.) above the top of the PEX and the piping shall be secured every 600 mm (24 in.). Use only fasteners supplied or approved by the manufacturer of the PEX pipe.

.7 Piping that passes through expansion joints shall be covered in protective polyethylene corrugated sleeving (flexible conduit) extending 380 mm (15 in.) on each side of the joint. Sleeving shall be secured on pipe to prevent movement during installation of thermal mass.

.8 Where piping exits the thermal mass, a protective conduit shall be placed around the pipe, with the conduit extending a minimum of 150mm (6”) into the floor and exiting by a minimum of 150 mm (6 in.). For penetrations at manifolds, use rigid PVC bend guides secured in place to prevent movement.

.9 At the time of installation of each circuit of pipe, connect the pipe to the correct manifold outlet and record pipe length for balancing. If manifold is not installed, cap the end of the pipe and label the pipe's circuit numbers along with “S” for supply and “R” for return. Connect pipes to manifold as soon as possible and record circuit lengths. All circuits shall be labeled to indicate circuit length and serviced area.

.10 The following precautions shall be taken in areas intended for carpet:

.1 Keep pipes 150 mm (6 in.) from all wall baseplates.

.2 Install metal guards where pipe will pass through wall baseplates and where carpet tack strips will be installed.

.11 The following precautions shall be taken in areas intended for hardwood flooring:

.1 Ensure that nailing areas for hardwood flooring, if nailing is required, are clearly marked and known for hardwood installers.

.12 If the radiant heating and/or cooling system substrate material (thermal mass) requires curing and/or has other limitations which can be influenced by the radiant heating and/or cooling system while in operation, then the radiant heating and/or cooling system shall not be put into operation until such time that the substrate material has fully cured or set according to the material requirements of the substrate manufacturer.

.13 The installer shall confirm minimum and maximum exposure temperatures for the substrate material (thermal mass) and shall ensure proper radiant heating and/or cooling operating temperatures.

3.4 Field quality control

.1 Filling, Testing & Balancing: Tests of hydronic heating and/or cooling systems shall comply with authorities having jurisdiction, and, where required, shall be witnessed by the building official.

.2 Pressure gauges used in testing and balancing shall show pressure increments of 1 psig and shall be located at or near the lowest points in the distribution system.

.3 Air Test

.1 Charge the completed, yet unconcealed pipes with air at a minimum of 40 psig.

.2 Do not exceed 150 psig.

.3 Use liquid gas detector or soap solution to check for leakage at manifold connections.

.4 Water Test

.1 Purge air from pipes.

.2 Charge the completed, yet unconcealed pipes with water.

.3 Take necessary precautions to prevent water from freezing.

.4 Check the system for leakage, especially at all pipe joints.

.5 Perform a preliminary pressure test pressurizing the system to the greater of 1.5 times the maximum operating pressure or 100 psig for thirty (30) minutes.

.1 As the piping expands, restore pressure, first at ten (10) minutes into the test and again at twenty (20) minutes.

.2 At the end of the thirty (30) minute preliminary test, pressure shall not fall by more than 8 psig from the maximum, and there shall be no leakage.

.6 After successfully performing the preliminary pressure test, perform the main pressure test immediately.

.1 The test pressure shall be restored and continued as the main test for two (2) hours.

.2 The main test pressure shall not fall more than 3 psig after two (2) hours.

.3 No leakage shall be detected.

.7 Pressure shall be maintained and monitored during installation of the thermal mass.

.1 If any leak is detected during installation of thermal mass, leak shall be found immediately and the area cleared for repair using manufacturer's approved repair coupling.

.2 Retest before covering repair.

.8 Complete inspection and furnish test reports supplied by the manufacturer of the system.

3.5 Cleaning

.1 Clean exposed surfaces upon completion of installation using clean, damp cloth. No cleaning agents are allowed.

.2 Comply with manufacturer's recommendations.

3.6 Protection

.1 Protect installation throughout construction process until date of final completion.

.2 Replace components that cannot be repaired.

End of section

1 General

1.1 General requirements

.1 Comply with the General Requirements of Section 20 01 00, Common Work Elements of Section 20 05 00 and Basic Materials and Methods of Section 26 05 05.

1.2 Work included

.1 Furnish and install, in accordance with the recommendations of the manufacturer, an “in-slab” electric heat distribution system. System shall use a self-regulating cable.

.2 Include all labour, materials transportation, equipment and services to install a complete “in-slab” snow melt heating systems where indicated on the drawings for the project.

1.3 Quality assurance

.1 All components of system shall be provided by one manufacturer.

.2 Ensure the in-slab heating system is designed in accordance with a “Certified Design Check List” complete and signed by a “Certified Designer” according to the instructions and testing methods furnished by the manufacturer.

1.4 Qualifications

.1 Manufacturer: Must be a company specializing in the Work of this Section with a minimum of ten (10) years documented experience.

.2 Installation shall be performed by qualified installers trained by the manufacturer in the procedures required for the in-slab electric snow melting systems and appropriately licensed for the jurisdiction where the installation will take place.

1.5 Delivery, storage and handling

.1 Deliver and store equipment in shipping containers with labeling in place.

.2 Store equipment in a safe place, dry, enclosed, under cover, in a well-ventilated area.

.3 Protect materials from damage by other trades.

.4 Equipment and cables shall be protected from oil, grease, paint, direct sunlight and other elements as recommended by manufacturer.

1.6 Submittals

.1 Product Data: Submit manufacturer's Technical Manual, submittal forms, catalog cuts, brochures, specifications, and installation instructions. Submit data in sufficient detail to indicate compliance with the contract documents.

.1 Submit manufacturer's instructions for installation.

.2 Submit data for equipment, fasteners and associated items necessary for the installation.

.2 Submit computer-generated system design.

.3 Drawings: Provide plans drawn to scale for all installation areas, including all routes of wiring between the snow melt controllers and snow melt surfaces.

.1 Indicate dimensions, descriptions of materials, general construction, component connections and installation procedures.

.2 Indicate design, schematic layout of system, including equipment, critical dimensions and slab penetration details.

.4 Certification

.1 Submit third-party certification results for the systems from an accredited testing laboratory.

.2 The design shall be approved by a professional appropriately licensed in the jurisdiction where the installation will take place, as being complete and accurate.

.5 Copy of the certificate indicating that the installer is certified in the installation of the manufacturer’s products.

.6 Maintenance Instructions: Submit product instructions for any maintenance required or recommended by manufacturer.

.7 Final “As-Built” loop layout drawings.

1.7 Warranty

.1 Provide a two (2) year manufacturer standard written warranty starting from date of Substantial Performance.

2 Products

2.1 Acceptable manufacturers

.1 Electrical Cable System – Raychem, Thermon, Pyrotenax, or approved alternate.

2.2 Electric cable system

.1 System Description; Complete surface snow-melting system for concrete and asphalt. System consists of self-regulating heating cable, connection kits, accessories, and temperature and moisture sensing control; monitoring; integrated ground-fault circuit protection; and BAS communication capabilities. Must comply with UL 515, CSA 22.2 No 130-03, and IEEE 515.1.

.2 Snow/ice melting systems shall have controls to prevent operation in warm weather.

.3 Heating Element: HDPE Jacketed Copper Sheathed MI Heating Cable, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable is capable of crossing over itself once without overheating. Electrical Insulating Inner Jacket and tinned-copper braid with polymer outer jacket.

.4 Surface mounted flush mount snow sensor. Capable of withstanding vehicle traffic. Built-in hold-on timer keeping heaters operating for an hour after snow stops to help ensure complete snow melting. The sensor sub-assembly shall be field replaceable without disturbing the pavement.

.5 Overhead snow sensor to detect falling or blowing precipitation before snow or ice begin to accumulate. This allows the control panel to begin managing the system. This sensor shall be roof mounted.

.6 Accessories

.1 Expansion Joint Kit

.2 Junction boxes

.3 UL-listed weatherproof enclosure suitable for terminating both ends of heating cable circuit.

.4 Provide Snow-Melting Caution Sign in accordance with Authority having Jurisdiction.

.5 Galvanized pre-punched strapping.

.7 Multi-Circuit, Distributed Digital Control System:

.1 Heating cable manufacturer shall provide two multi-circuit snow/ice melting controllers with built-in GFPD compatible with selected heating cables.

.2 Electronic snow/ice melting controller shall have GFPD with adjustable trip levels of 30, 60, and 120 mA.

.3 Electronic snow/ice melting controller shall be capable of operating with supply voltages of 208V three phase.

.4 Electronic snow/ice melting controllers shall be capable of supporting up to six aerial or slab mounted temperature and moisture sensors.

.5 Controller Enclosure Type: NEMA 1.

.6 Control transformer included

.7 Main circuit breaker included

.8 Electronic snow/ice melting controller shall have an integrated high-limit temperature sensor.

.9 Electronic snow/ice melting controller shall have contacts (10 mA dry switch contact) to interface with Building Automation System.

.1 Inputs: Override On, Override Off.

.2 Outputs: Supply, Snow, Heat, High Temp, Alarm.

.10 Digital controller shall have c-UL-us approvals.

3 Execution

3.1 General

.1 Installation of snow melt system shall be performed by Division 26. Coordinate supply of material and BAS tie in with requirements of Division 26.

3.2 Examination

.1 Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

.1 Ensure that surfaces in contact with electric heating cables are free of burrs and sharp protrusions.

.2 Ensure that surfaces and substrates are level and plumb.

.2 Pre-installation Testing:

.1 Prior to installing heating cable, an insulation resistance test is performed by installing Contractor to ensure integrity of heating cable as described in installation and maintenance manual.

.3 Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 Preparation

.1 Protect all heating cable ends from moisture ingress until cable is terminated with end seals.

.2 Protection of In-Place Conditions:

.1 If there is any delay between installation of heating cables and placement of topping course, take the following precautions to protect the installation:

.1 Record post-installation test results immediately.

.2 Do not energize cables.

.3 Mechanically protect cables so they cannot be damaged by pedestrian or vehicular traffic, paint, welding, falling objects, inclement weather, or other inappropriate exposure.

3.4 Installation, Embedded

.1 Do not energize cables embedded in concrete or asphalt until those assemblies are cured.

.2 All heat tracing components including power connections, splices, tees, crosses, or end seal, must be installed above grade and protected from abuse or damage. By NEC and CEC, electrical connections are not permitted to be installed below grade.

.3 Install heating cable with heat-conductive fill materials such as asphalt or concrete to ensure direct contact with finished radiant surfaces.

.4 For asphalt paving Install cables after applying bituminous binder course to lower base; ensure that second bituminous binder course is applied to cables or mats before pouring finish topping.

.5 Provide a flush-mounted box to identify embedded heating array. Coordinate with paving Sections.

.6 Install embedded electric heating-cable or identification box where indicated in pavement before pavement work is completed.

.7 For cast-in-place concrete paving Stamp concrete with embedded electric heating-cable identification in accordance with NFPA 70 and complying with "Cast-in-Place Concrete" specifications.

3.5 Sensors and Controllers

.1 General:

.1 Mount sensors in upright position in an area clear of overhead trees, wires, eaves, and similar, and not at risk from falling debris. Avoid exposure to artificial heat-sources and shock vibration.

.2 Select location representative of anticipated precipitation conditions in areas where snow-melting system is installed.

.3 Consider pavement-mounted sensor for snow melting on pavement.

.4 Mount precipitation sensor in pavement.

.5 Provide power for sensor in accordance with electrical codes and standards.

.2 Slab temperature sensor for the following:

.1 Group Control and Power Distribution Panel:

.1 Install metallic conduit, 3/4 inch- (19-mm-) minimum diameter, for accommodation of the slab thermistor between runs of heating cable prior to topping course pour. Conduit shall not cross runs of heating cable, and to end no less than 18 inches (450 mm) within heated section of slab. Seal conduit at its extent to prevent ingress of paving material during pour and moisture after.

.2 After topping course is complete, insert slab temperature sensor to end of previously installed conduit. Use fish tape (or similar) to push thermistor in, and abandon in-place, for the dual purpose of ensuring it gets to end and allowing future removal.

.2 Distributed Control Network:

.1 Install metallic conduit, 3/4 inch- (19-mm-) minimum diameter, for accommodation of the slab-sensing RTD between runs of heating cable prior to topping course pour. Conduit to not cross runs of heating cable, and to end no less than 18 inches (450 mm) within heated section of slab. Seal conduit at its extent to prevent ingress of paving material during pour and moisture after.

.2 After topping course is complete, insert slab temperature sensor (RTD) to end of previously installed conduit. Use fish tape (or similar) to push thermistor in, and abandon in-place, for the dual purpose of ensuring it gets to end and allowing future retrieval without undue tension on sensor assembly itself.

.3 Controls Contractor shall provide monitoring of electronic snow/ice melting controllers in the BAS.

.1 Outputs: Supply, Snow, Heat, High Temp, Alarm.

3.6 Connections

.1 Division 26 shall provide and install all required raceways and junction boxes..

.2 Ground equipment in accordance with Division 26.

.3 Connect wiring in accordance with Division 26.

3.7 Field Quality Control

.1 Manufacturer's Field Service: Initial start-up and field testing of system shall be performed by factory technician in accordance with Owner's requirements.

.2 Contractor to perform the following tests and inspections during installation:

.1 Heating cable is tested for insulation resistance when received at Project site before installation.

.2 Heating cable is tested for insulation resistance after installation, but before insulation is installed.

.3 Heating cable is tested for insulation resistance after insulation is installed to manufacturers requirements.

.4 All results must meet manufacturer's specification.

.5 Test cables for electrical insulation integrity throughout installation.

.1 Be prepared to halt installation of topping material if a break in the insulation integrity is identified.

.2 Block out areas of damaged cable for later repair. Leave 18 inches (457 mm) exposed on either side of cable to make splice repair.

.3 Resume pour once area for splice is in place.

.6 Test insulation integrity before energizing.

.7 Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

.8 Repeat tests for continuity, insulation resistance, and input power after applying finished surface on heating cables.

.3 Electric heating cables will be considered defective if they do not pass tests and inspections in accordance with manufacturer's requirements.

.4 Prepare test and inspection reports.

3.8 Protection

.1 Protect installed heating cables, including non-heating leads, from damage and moisture ingress during construction.

.2 Remove and replace damaged electric heating cables.

.3 Comply with manufacturer's written instructions for maintenance service.

End of section

1 General

1.1 Section includes

.1 Steam Injection Humidifier.

.2 Distribution Manifold.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 References

.1 ARI 610 - Central System Humidifiers.

.2 ARI 630 - Selection, Installation and Servicing of Humidifiers.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Provide data on humidifiers and accessories including performance ratings rated capacity, and electrical characteristics and connection requirements.

.4 Manufacturer's Installation Instructions.

1.5 Quality assurance

.1 Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three (3) years documented experience.

1.6 Regulatory requirements

.1 Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 Warranty

.1 Section 20 01 00 – Mechanical General Requirements: Submittals for project closeout.

.2 Provide two year manufacturer warranty starting from date of Substantial Performance for humidifier unit except the cylinder.

2 Products

2.1 Humidifier

.1 The electrode steam generating system shall use a potable water supply.

.2 Enclosure shall be an 18-gauge stainless steel frame with resin cover suitable for finished spaces. Enclosure frame shall constitute a drip pan, having a threaded connection for drain piping. A separate compartment shall house electrical devices and shall be secured to prevent accidental contact with electrical components. The front exterior of the cabinet shall contain the microprocessor controller's digital keypad.

.3 Cleanable vaporizing chamber shall be stainless steel with Heli-arc welded seams. The evaporating chamber shall be mounted on slide rails. Electrical, water supply and drain connections shall have unions and plugs to allow convenient removal of the evaporating chamber for cleaning.

.4 The humidifier frame shall have prepunched keyhole-style mounting holes located on 16" (406 mm) centers for ease of wall mounting and leveling.

.5 Steam outlet on top of tank shall be configured to connect to:

.1 A dispersion unit in a duct via hose or pipe, or

.2 A space distribution unit (SDU) constructed with an 18-gauge stainless steel frame, integral drain pan and resin cover matching the electric steam humidifier.

.6 Immersion heater(s): Heater(s) shall be Incoloy alloy-sheathed resistance type designed for no more than 86 watts per square inch and shall be mounted on the vaporizing chamber's removable cover.

.7 Temperature sensor: A factory mounted sensor, with a temperature range of -40 to 248 °F (-40 to 120 °C) shall be mounted on the humidifier to enable the following functions:

.1 Maintain the evaporating chamber water temperature above freezing

.2 Maintain a user-defined preset evaporating chamber water temperature

.3 Allow rapid warm-up of water in evaporating chamber after a call for humidity, providing 100% operation until steam production occurs

.4 Provide backup over-temperature protection for the over-temperature switch

.8 Over-temperature switch: A factory-mounted and -wired UL-listed limit control sensor with manual reset shall sense an over-temperature condition and de-energize heater circuit controls.

.9 Water requirements: The humidifier shall be capable of generating steam from tap, softened or DI/RO water.

.10 Drain: An electric drain valve shall be mounted on humidifier assembly to allow tank to drain automatically at the end of a humidification season.

2.2 Humidifier CONTROLS

.1 Time-proportioning (TP) modulation control: The humidifier shall cycle a single output on and off corresponding to an input demand signal.

.2 Vapor-logic® microprocessor controller with the following features or functions:

.1 Web interface and server, included standard on all models:

.2 Web interface shall have same functionality as Vapor-logic keypad/display

.3 Web interface shall allow multiple remotely located users to simultaneously view system operation and/or change system parameters.

.4 Web interface shall have password-protected secure access.

.5 Web interface shall be compatible with standard Internet browsers.

.6 Web interface shall connect directly to a personal computer or through a system network via Ethernet cable.

.1 Automatic cable configuration shall allow straight-through or crossover cables.

.7 Interoperable with any Modbus® network

.3 Redundant over-temperature safety control

.4 Fully modulating (0% to100%) control of humidifier outputs

.5 PID control capability with field-adjustable settings

.6 Water level control for softened or hard water:

.1 Automatic refill, low water cutoff, field-adjustable skimmer bleedoff functions and automatic drain-down of humidifier. System shall consist of:

.1 A water level sensing unit comprised of three metallic probes screwed into a threaded probe head. Probe head shall incorporate probe isolation chamber to eliminate short-circuiting between probes caused by mineral coating of probe head. Probe head shall be mounted on the humidifier assembly.

.2 A solenoid operated fill valve factory mounted on the humidifier assembly

.3 End-of-season drain automatically drains humidifier tank after a user-defined period of system inactivity.

.7 Temperature sensor: A factory mounted sensor, with a temperature range of -40 to 248 °F (-40 to 120 °C) mounted on the humidifier to enable the following functions:

.1 Maintain the evaporating chamber water temperature above freezing

.2 Maintain a user-defined preset evaporating chamber water temperature

.3 Allow rapid warm-up of water in evaporating chamber after a call for humidity, providing 100% operation until steam production occurs

.8 USB port on the control board for software updates, data backups, and data restoration

.9 Up-time optimizer function to keep humidifier(s) operating through conditions such as fill, drain, or run-time faults, as long as safety conditions are met, minimizing production down-time

.10 Real-time clock to allow time-stamped alarm/message tracking, and scheduled events

.11 Factory commissioning of humidifier and control board, including system configuration as-ordered

.12 Keypad/display operable within a temperature range of 32 to 158 °F (0 to 70 °C), and that provides backlighting for viewing in low light

.13 Alarms, unit configuration, and usage timer values shall remain in nonvolatile memory indefinitely during a power outage.

.14 The capability to monitor, control, and/or adjust the following parameters:

.1 Relative humidity (RH) set point, actual conditions in the space (from humidity transmitter), RH offset

.2 Dew point set point, actual conditions in the space (from dew point transmitter), dew point offset

.3 Relative humidity (RH) duct high limit set point (switch) and actual conditions

.4 Relative humidity (RH) duct high limit set point, actual conditions (from transmitter), high limit span, and high limit offset

.5 Total system demand in % of humidifier capacity

.6 Total system output in lbs/hour (kg/h)

.7 Drain/flush duration

.8 End-of-season drain status (on standard water systems and if ordered as a DI water option) and hours humidifier is idle before end of season draining occurs

.9 Window glass surface temperature (in % RH offset application using sensor ordered as an option) with programmable offset

.10 Air temperature or other auxiliary temperature monitoring with programmable offset (using sensor ordered as an option)

.11 System alarms and system messages, current and previous

.12 Adjustable water skim duration

.13 Programmable outputs for remote signaling of alarms and/or messages, device activation (such as a fan), or for signaling tank heating and/or steam production

.14 System diagnostics that include:

.1 Test outputs function to verify component operation

.2 Test humidifier function, by simulating demand to validate performance

.3 Data collection of RH, air temperature, water use, energy use, alarms, and service messages for viewing from the keypad/display or Web interface

.15 Service notification scheduling

.16 Password-protected system parameters

.17 Keypad/display or Web interface displays in English, French, Dutch, Spanish, or German languages

.18 Numerical units displayed in inch-pound or SI units

.15 Interoperability using BACnet MS/TP.

.16 Multiple humidifier tank control. Vapor-logic shall be programmed and configured at the factory to control multiple humidifier tanks. Controller functions shall include all Vapor-logic functions listed above plus:

.17 Automatic run-time balancing. The controller shall assign duty to all humidifier tanks in the multi-tank group such that each humidifier accrues approximately the same hours of duty, thereby ensuring equal wear across all humidifiers in the multi-tank group.

.18 One Vapor-logic keypad/display shall be included with each multi-tank group.

.19 Control input accessory options:

.1 Humidity transmitter, duct: Humidity transmitter shall be a duct-mounted device that measures from 0% to 100% RH range and provides a linear output (10% to 90% RH) from 4 to 20 mA. Accuracy ± 2% RH. Supply voltage 21 VDC. Operating temperature range: -4 to 140 °F (-20 to 60 °C).

.2 Airflow proving switch, sail type: Airflow proving switch shall be a sail-operated electric switch for field installation. Switch makes @ 250 fpm (1.3 m/s), breaks @ 75 fpm (0.4 m/s). Maximum operating temperature for sail: 170 °F (77 °C). Maximum operating temperature for switch: 125 °F (52 °C).

2.3 Humidifier accessories

.1 Pump, low-flow, high-temperature: Pump shall be suitable for pumping water up to 212 °F (100 °C). Maximum pump flow rate shall be 3.8gpm (228 gph) with a 12-foot head (36 kPa). Pump shall have a 1-gallon cast aluminum reservoir with a 3/8" pipe thread (DN10) outlet connection, two 1-1/4" (DN32) inlet openings, and integral float switch. Pump shall be used with 115 VAC. Pump also available with 230 VAC. Pump shall be UL recognized and wired per NEC requirements.

.2 Pump, high-flow, high-temperature: Pump shall be suitable for pumping water up to 212 °F (100 °C). Maximum pump flow rate shall be 55 gpm (3300 gph) with a 12-foot head (36 kPa). Pump shall have a 4-gallon cast aluminum reservoir with vapor seal, a 3/4" pipe thread (DN20) outlet connection, a 1-1/2" pipe thread (DN40) inlet connection, and integral float switch. Pump shall be used with 115 VAC. Pump can be wired for use with 115/230 VAC. Pump shall be UL recognized and wired per NEC requirements.

.3 Pump, high-flow, low-temperature: Pump shall be suitable for pumping water up to 150 °F (65.5 °C). Maximum pump flow rate shall be 55 gpm (3300 gph) with a 12-foot head (36 kPa). Pump shall have a 2-gallon cast aluminum reservoir, a 1" pipe thread (DN25) outlet connection, a 1-1/2" pipe thread (DN40) inlet connection, and integral float switch. Pump shall be used with 115 VAC. Pump can be wired for use with 115/230 VAC. Pump shall be UL recognized and wired per NEC requirements.

.4 Drane-kooler: A thermostatically controlled water valve shall meter an amount of cold water into a stainless steel mixing chamber to temper 212 °F (100 °C) water with a 6 gpm (0.38 l/s) in-flow rate to a 140 °F (60 °C) discharge temperature to sanitary system.

2.4 Humidifier dispersion (Rapid-sorb® dispersion panel)

.1 Each tube bank shall consist of a horizontal header/separator and designated quantity of vertical dispersion tubes necessary to achieve the required steam capacity and absorption distance.

.2 The humidifier shall provide absorption characteristics that preclude water accumulation on any in-duct surface within 7" (178 mm) of the humidifier tube panel while maintaining conditions of 30% maximum relative humidity at a minimum of 68.2°F in the duct airstream.

.3 Air pressure loss across the humidifier panel shall not exceed 0.1" water column at a duct air velocity of 810fpm.

.4 Header/separator shall span the width of the duct, be constructed of stainless steel and be fitted with connections for dispersion tubes.

.5 The dispersion tubes shall extend the height of the duct and shall be fitted with two rows of tubelets on the diametric centerline and spaced 1-1/2" (38 mm) apart.

.6 Each tubelet shall be made of a thermal-resin material designed for high steam temperatures.

.7 Each tubelet shall extend through the wall of and into the center of the dispersion tube and contain a steam orifice sized for its required steam capacity.

.8 For securing the upper ends of the tubes, a 3/4" x 2" (19 mm x 50 mm) stainless steel L-bracket shall be furnished, which the installer shall attach to the duct or housing.

.9 Option: High-efficiency dispersion tubes

.10 Dispersion tubes shall be insulated with a plenum-approved insulating material for in-duct installation and have an R-value not less than 0.5 at a thickness not more than 0.125" (3.2 mm), for minimal increase in dispersion tube diameter.

.11 Airstream heat gain shall not exceed the values as scheduled; the values shall be supported by the manufacturer's published data.

.12 Insulating material shall meet the following criteria at 0.125" (3.2 mm) thickness:

.13 Fire/smoke index shall be 0/0 per any of the following test procedures:

.1 UL 723 fire/smoke index (Test for Surface Burning Characteristics of Building Materials)

.2 NFPA 255 (Standard Method of Test of Surface Burning Characteristics of Building Materials)

.3 ASTM E84 (Surface Burning Characteristics for Materials Used in Plenums)

.14 Stable up to 300 °F (148 °C) continuous — to prevent material degradation, hardening, or crumbling at high temperatures

.15 Closed-cell construction does not absorb water or support microbial growth — to negate the need for vapor barriers and jackets

.16 Non-toxic and pure as documented in manufacturer's data — to prevent off-gassing and to facilitate use in clean rooms, pharmaceutical applications, and food industries

.17 Will not degrade when exposed to UVC light — to negate the need for UV wraps

.18 Continuous, seam-welded, and held in place without bands or clamps — to minimize surfaces for the accumulation of particulate matter

3 Execution

3.1 Installation

.1 Install humidifier in accordance with manufacturer’s instructions.

.2 Install flexible hose or rigid pipe between humidifier outlet and steam distribution pipe(s). Insulate the complete length.

.3 Provide and install condensate piping from condensate separator to nearest floor drain.

.4 Provide isolating valve, strainer and connection to steam supply.

.5 Provide and install condensate traps and drains on steam distribution grids

3.2 Start-up

.1 Furnish the services of a trained representative of the equipment manufacturer to supervise the installation, wiring, set up and testing of the humidifier system. Upon completion of the installation, the manufacture shall instruct a representative of the owner on the proper operation of the system.

End of section

1 General

1.1 Section includes

.1 This section specifies the requirements for Building Automation System Controls.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00, Testing, Adjusting and Balancing of Section 20 05 93 and the Common Work Elements of Section 20 05 00.

.2 Read and conform to:

.1 The Contract CCDC 2, Stipulated Price Contract as amended in the Contract Documents;

.2 Division 01 requirements and documents referred to therein.

1.3 Description

.1 The work of the single BAS Contractor shall be as defined individually and collectively in all sections of this division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.

.2 The BAS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BAS.

.3 Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.

.4 Manage and coordinate the BAS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.

.5 The BAS as provided shall incorporate, at minimum, the following integrated features, functions and services:

.1 Operator information, alarm management and control functions.

.2 Enterprise-level information and control access.

.3 Information management including monitoring, transmission, archiving, retrieval, and reporting functions.

.4 Diagnostic monitoring and reporting of BAS functions.

.5 Offsite monitoring and management access.

.6 Energy management

.7 Standard applications for terminal HVAC systems.

.8 Indoor Air Quality monitoring and control.

1.4 Quality assurance

.1 General

.1 The system shall comply with BACnetTM communication protocol format and capable of communicating with all controllers, control devices, etc.

.2 The BAS Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Automation Systems.

.3 The BAS Contractor shall be a recognized national manufacturer, installer and service provider of BAS.

.4 The BAS Contractor shall have a branch facility within a 160 km (100 mile) radius of the job site supplying complete maintenance and support services on a twenty four (24) hour, seven (7) day-a-week basis.

.5 As evidence and assurance of the contractor’s ability to support the Owner's system with service and parts, the contractor must have been in the BAS business for at least the last ten (10) years and

have successfully completed total projects of at least ten (10) times the value of this contract in each of the preceding five years.

.6 The Building Automation System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Automation Systems, and shall be the manufacturer's latest standard of design at the time of bid.

.2 Quality Management Program

.1 Designate a competent and experienced employee to provide BAS Project Management. The designated Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BAS Contractor. At minimum, the Project Manager shall:

.1 Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.

.2 Manage the financial aspects of the BAS Contract.

.3 Coordinate as necessary with other trades.

.4 Be responsible for the work and actions of the BAS workforce on site.

1.5 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Shop Drawings, Product Data, and Samples

.1 Refer to Section 20 01 00 – Mechanical General Requirements.

.2 Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages.

.3 Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BAS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Sponsor.

.4 Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.

.4 Control Drawings:

.1 Prepare two (2) sets of control diagrams and review them with the Consultant within thirty (30) days of award of contract. Review prior to this presentation shop drawings for all mechanical equipment and ensure that interfacing of controls with such mechanical/electrical devices has been addressed appropriately.

.2 Submit eight (8) copies of control schematics following satisfactory review, fully describing the sequence of operation of controls prior to installation of this work.

.3 Indicate on control diagrams positions, model numbers, setting of proportional band, gain and authority percent, setpoint and reset schedules, air piping and wiring layouts. Show areas served as well as system numbers on diagrams. Also show size or capacity.

.4 Submit valve and damper schedules indicating size, configuration, capacity and locations.

.5 Refer to Section 20 05 53 – Mechanical Identification for valve tagging. Number valves in accordance with this section or format provided by the Owner.

.5 Operation and Maintenance Manuals

.1 Refer to Section 20 01 00 – Mechanical General Requirements.

.2 Three (3) copies of the Operation and Maintenance Manuals shall be submitted to the Consultant prior to substantial completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BAS provided:

.1 Table of contents.

.2 As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.

.3 Manufacturers product data sheets or catalog pages for all products including software.

.1 System Operator's manuals.

.2 Archive copy of all site-specific databases and sequences.

.3 BAS network diagrams.

.4 Interfaces to all third-party products and work by other trades.

.3 The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

.4 On-Line documentation: After completion of all tests and adjustments the contractor shall provide a copy of all as-built information and product data to be installed on a customer designated computer workstation or server.

1.6 References

.1 National Fire Protection Association (NFPA) Standards.

.2 National Electric Code (NEC) and applicable local Electric Code.

.3 Underwriters Laboratories (UL) listing and labels.

.4 UL 864 UUKL Smoke Control

.5 UL 268 Smoke Detectors.

.6 UL 916 Energy Management

.7 NFPA 70 - National Electrical Code.

.8 NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.

.9 NFPA 92A and 92B Smoke Purge/Control Equipment.

.10 Factory Mutual (FM).

.11 American National Standards Institute (ANSI).

.12 National Electric Manufacturer's Association (NEMA).

.13 American Society of Mechanical Engineers (ASME).

.14 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) [ASHRAE 62 IAQ].

.15 Air Movement and Control Association (AMCA).

.16 Institute of Electrical and Electronic Engineers (IEEE).

.17 American Standard Code for Information Interchange (ASCII).

.18 Electronics Industries Association (EIA).

.19 Occupational Safety and Health Administration (OSHA).

.20 American Society for Testing and Materials (ASTM).

.21 Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.

.22 Americans Disability Act (ADA)

.23 ANSI/ASHRAE Standard 195-2008 (BACnet)

1.7 Warranty

.1 Provide two-year labor and material warranty starting from date of Substantial Performance on the BAS.

.2 If within twenty-four (24) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BAS Contractor at the cost of the BAS Contractor.

.3 Maintain an adequate supply of materials within 160 km (100 miles) of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BAS Contractor's normal business hours.

1.8 Approved control system providers

.1 Johnson Controls;

.2 Total Control Canada;

.3 Yorkland Controls; or

.4 Approved alternate.

.1 The above list of providers applies to operator workstation software, controller software, the custom application programming language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (i.e., sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.9 Design Considerations

.1 Equipment Selection.

.1 The following must be considered when selecting equipment (where possible) for new or replacement projects throughout the ROD facilities.

.1 New and replacement Air Handling units must have factory installed BACnet MSTP or BACnet IP controllers.

.2 New and replacement Boilers must have factory installed BACnet IP controllers.

.3 New and replacement Make up Air Units must have factory installed BACnet MSTP controllers.

.4 New and replacement Chillers must have factory installed BACnet IP controllers.

.5 New and replacement CO and NO2 systems must be provided with a BACnet IP communication card.

.6 New and replacement Dehumidifiers must have factory installed BACnet IP controllers.

.7 New and replacement lighting systems must be provided with a BACnet IP communication card.

.2 Field Controllers

.1 All field controllers must be BACnet MSTP.

.3 Supervisory Network Controllers

.1 Any NAE Supervisory devices must not exceed more than 80% capacity, without approval from ROD FMO.

.2 Provide a 250Va UPS for all new and replacement NAEs.

.3 Refer to Appendix C for schematic diagrams on installation UPS, NAE and transformers.

.4 All HVAC equipment which contains a fan or coil must have a SAT sensor installed at the discharge.

.5 Network devices.

.1 I.T. Switches.

.1 Switches should have sufficient capacity to accept new BACnet IP connections on new and replacement projects. Consultants or Contractors must contact the Region of Durham's CS-IT Department to confirm capacity.

.6 Domestic Water Heater/Boilers

.1 Package Controllers

.1 Boilers and domestic water heaters should be supplied with factory installed points for the following;

.1 General Alarm

.2 Running status

.3 Trouble alarm

.4 Supply water temperature

.5 Hot water recirculation temperature

.6 Pump Status

.7 Generators

.1 Package Controllers

.1 Generators should be supplied with factory installed points for the following;

.1 General Alarm

.2 Running status

.3 Trouble alarm

.2 If the fuel tank is integrated with the generator, include the following;

.1 High tank alarm.

.2 High high tank alarm.

.3 Low tank alarm.

.4 Integrated Fuel Measurement system.

.5 Fuel Leak alarm

.6 Diesel Generator battery alarm

.7 Over fill protections

.3 Include the monitoring of generator signals in BAS.

.2 Generators, main tanks and all associated equipment must be on a dedicated field controller.

.1 All dedicated field controllers must be connected to emergency power and be UPS connected.

.3 Fuel Measurement

.1 Generator tanks shall come with a fuel measurement device capable of sending a 0-10 VDC signal or 4-20 mA to the BAS field controller.

.8 ATS

.1 Include the monitoring of ATS signals in BAS, as listed in Section 26 24 02 – Service Entrance Switchboard. Including:

.1 Utility Source Available

.2 Generator Source Available

.3 Switch Position Utility Power

.4 Switch Position Generator Power

.9 Fire Alarm Control Panel

.1 Include the monitoring of Fire Alarm Control Panel signals in the BAS, as listed in Section 28 31 00 – Fire Alarm System. Including:

.1 Alarm

.2 Supervisory

.3 Trouble

.10 Snow Melting System

.1 Controls Contractor shall provide monitoring of electronic snow/ice melting controllers in the BAS.

.1 Outputs: Supply, Snow, Heat, High Temp, Alarm.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General description

.1 The BMS shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.

.2 The BMS shall consist of the following:

.1 Application and Data Server

.2 Network Engine(s)

.3 Equipment Controller(s)

.4 Input/Output Module(s)

.5 Local Display Device(s)

.6 Distributed User Interface(s)

.7 Network processing, data storage and communications equipment

.8 Other components required for a complete and working BMS

.3 The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

.4 System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

.1 The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

.2 The System shall maintain all settings and overrides through a system reboot.

.3 System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

.5 The System shall comply with the following International Code Council (ICC) Codes:

.1 Building Officials and code Administrators International (BOMA) model code.

.2 International Conference of Building Officials (ICBO) model code.

.3 Southern Building Code Congress International (SBCCI) regulations.

2.3 BMS System Architecture

.1 Automation Network

.1 The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off the shelf” products available through normal PC vendor channels.

.2 The BMS shall network multiple user interface clients, application and data servers, network engines, system controllers and application-specific controllers including but not limited to:

.1 Application and Data Server

.2 Network Engines

.3 Network Control Engines

.4 Equipment Controllers

.5 VAV Box Controllers

.6 Third Party BACnet controllers and peripheral devices with compatibility listed by BACnet International

.7 Application and Data Server

.3 All BMS devices on the automation network shall be capable of operating at a minimum communication speed of 100 Mbps, with full peer-to-peer network communication.

.4 Network Security – To protect the BMS from unauthorized users and computer hackers the Automation Network shall support HTTPS with TLS 1.2 between components, including the Application and Data Server(s), Network Engines, Mobile User Interface and Site Management Portal. Self-signed certificates are installed on supported products, with the option of configuring trusted certificates. Computing devices supplied by the BMS vendor will automatically shut down unused ports to deter unauthorized access.

.5 The automation network will be compatible with other enterprise-wide networks. Automation network components of the BMS shall be connected to the Owner's enterprise network and share resources with it by way of standard networking devices and practices.

.1 Owner shall provide and maintain all infrastructure components for the Automation network, including switches, routers, firewalls, etc.

.2 All data drops and IP addresses to and for BACnet IP components of the BMS shall be provided by the Owner.

.2 Control Network

.1 Network Engines shall provide supervisory control over the control network and shall selectively support the following communication protocols:

.2 BACnet Standard Master-Slave/Token-Passing (MS/TP) Bus Protocol ASHRAE SSPC-135:

.1 The Network Engines shall be BTL listed/certified.

.2 The Network Engines shall be tested and certified as a BACnet Building Controller (B-BC) profile.

.3 Modbus® TCP and RTU

.3 Control networks shall provide either “Peer-to-Peer”, Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.

.4 Control network shall support digital controllers as indicated in plans and specifications.

.5 Default control network communication protocol for this project shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.

.6 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 Integration

.1 Hardwired

.2 Analog and digital signal values shall be passed from one system to another via hardwired connections.

.1 There will be one separate physical point on each system for each point to be integrated between the systems.

.3 BACnet Protocol Integration – BACnet

.4 The neutral protocol used between systems will be BACnet IP and comply with the ASHRAE BACnet standard 135.

.1 A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

.2 The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

2.4 Metering

.1 Lighting, HVAC, Receptacle, and Solar PV panel circuits will be individually metered via panel integrated current transformers for each branch. A panel integrated metering module will process all received branch current information and transfer digitally to the BAS. Meters must record at intervals of one hour or less, record consumption and demand, be capable of storing 36 months of data, and be capable of reporting hourly, daily, monthly and annual energy use.

2.5 User Interface

.1 Dedicated Web Based User Interface

.1 Where indicated on plans the BMS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. Real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Engines and Data Server(s) to facilitate greater fault tolerance and reliability.

.2 Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically, it must be implemented to conform to the following interface standards.

.3 Edge or Google Chrome or Safari for user interface functions.

.1 Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions.

.2 Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports.

.3 Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.

.4 PC Hardware/Software – The personal computer(s) shall be configured as specified in the Computing Hardware and Software section.

.5 Provide one operational device as herein specified and located on plans.

.2 Mobile, Web Based, User Interface (MUI)

.1 General

.1 The mobile, web-based, user interface shall be HTML5-compliant and provide access to the system from

smartphones, tablets, portable and desktop computers. User Interfaces that require software installation on the client device (e.g. Java, Microsoft Silverlight®, Adobe® Flash®), or software downloads from an online app store shall not be acceptable for these purposes.

.2 The mobile user interface shall provide system operators with a simple location-based navigation approach to finding information, including the ability to search for any location by name and to bookmark a location in a standard browser.

.3 The mobile user interface shall organize and display information using customer specific locations and spaces. At a minimum, the user interface shall provide:

.1 Organization of all space, equipment and point information in a familiar way (using standard equipment names and location descriptions), reducing the need for extensive training prior to use.

.2 A navigation mechanism or tree for users to select the specific location or space for accessing information – only spaces and locations in the navigation tree or equipment serving that space, nothing more.

.3 The ability to search for and/or bookmark any location, space, or equipment by name for quick access to critical or troublesome areas.

.4 Application of the same navigation mechanisms across any client device (e.g. Smart phone, tablet, personal computer) for consistency and ease of use.

.3 The same user interface elements shall be accessible from any type of personal computer or mobile device running any type of operating system supported (e.g. iOS, Android, Windows®). It shall automatically adapt and optimize the display for the screen size and touch screen navigation.

.4 The user interface shall provide support for up to 50 concurrent users from individuals with defined access to the system.

.5 Navigation Trees

.1 A dedicated location-based navigation tree shall be provided as part of the user interface in order to navigate to specific places within the facility on a hierarchical basis (typ. Facility, Building, Wing, Floor, Room.)

.2 The location-based tree shall use place names familiar to the operator without training or familiarization regarding special codes and conventions utilized in the generation of the BMS.

.3 Clicking or tapping on a location name in the tree shall display the home page associated with the space and simultaneously expand the tree to display the next level of spaces below the one selected.

.4 It shall be possible for qualified users to view a navigation tree of devices connected to the BMS network to enable troubleshooting of equipment and communications. Clicking or tapping on the Network Icon at the top of the Navigation Tree will access this alternate view. Users without the necessary access rights shall not see the Network Icon.

.5 A click or tap on a device in the network tree shall display a dashboard for that device including information regarding related equipment and access to a separate focus view of commandable points associated with the piece of hardware. A click or tap on such a point shall display a control dialogue box allowing the user to modify or command that point as indicated. The dialog box shall contain an annotation box for describing why the action was taken or special circumstances that apply.

.6 Specific hardware and software types in the Network tree shall also include access to one or more the following views in their dashboard depending on hardware type or network element (e.g. MS/TP trunk):

.1 Summary View

.2 Diagnostic View

.3 Network View

.4 Trend View

.7 It shall be possible to hide the Network Tree and return to the Spaces Tree at any time by clicking on the Spaces Icon above the tree.

.8 It shall be possible to restrict user access to any space in the Spaces Tree and thereby prevent manipulation of equipment associated with the space.

.6 Dashboard Displays

.1 The user interface shall provide the ability to view equipment visualizations, floor plans, and/or other graphics on mobile or desktop client devices in a browser environment, without the need for additional plugins or software. Graphics shall be accessible via a space (for floorplans, campus maps, etc.) or equipment dashboard.

.2 Standard dashboards shall be configured for each defined space including one of the following predefined or custom elements:

.1 Equipment Serving Space

.2 Potential Problem Areas

.3 Equipment Summary

.4 Graphic Display (if specified)

.5 Schedule

.3 Standard dashboards shall be configured for each system or device (typ. mechanical or electrical equipment) including the following predefined or custom elements:

.1 Trend

.2 Equipment Activity Summary

.3 Equipment Relationships Summary

.4 Equipment Data

.5 Graphic Display (if specified)

.6 Schedule

.4 Users with appropriate permissions shall have access to a Dashboards Manager that can change the display order of Summaries and Data elements, add or remove elements and apply custom dashboards layouts to equipment and space by type.

.5 Dashboard Manager shall apply dashboards to spaces or equipment based on the viewing platform (Desktop/Tablet or

Phone) in order to tailor the user experience to the needs of the specific user base.

.6 Default dashboard displays by space and equipment type shall be created per the guidelines in this specification or by mutual agreement with the owner's representative.

.7 Alarm Management

.1 The user interface shall provide a single display of all potential issues in a facility including items currently in alarm, warning, override, out-of-service and offline.

.2 The user interface shall provide notification of new alarms, visually and audibly.

.3 The user interface shall provide the ability to view a summary of alarms, including a chart of the number of alarms in each of the defined alarm priority ranges. The priority ranges should be filterable.

.4 The user interface shall provide the capability to view multiple occurrences of the same alarm, ultimately providing the ability to acknowledge or discard all occurrences of the alarm in a single action.

.5 The user interface shall provide the capability to view, and filter on, all alarms present in a well-defined mechanical system using the equipment serving equipment relationships.

.6 The user interface shall provide the capability to acknowledge and discard all occurrences of at least 1000 alarms in one operation.

.7 The user interface shall provide the user with the understanding of what physical space is being affected when an alarm occurs. The user interface shall provide the ability to filter alarms by physical space affected when the alarm occurred.

.8 The user interface shall provide the capability to monitor alarms 24/7 without requiring an active login to the system, accessible via segregated web page. The user interface shall provide the capability to enabled or disable the 24/7 alarm monitor mode if desired.

.9 The user interface shall provide the capability to annotate alarms using a pre-defined selection list or by providing custom text.

.10 The user interface shall provide the capability to filter down alarm list and bookmark the filtered list, allowing automatic filtering to be applied when the bookmark is accessed.

.11 It shall be possible to export a .csv or .pdf copy of the currently displayed alarm list.

.12 If an alarm is not acknowledged or discarded by recipients within a user-selected time, the alarm shall be sent to an additional set of recipients.

.8 Send Announcement

.1 Administrative users should have the ability to alert staff of planned outages in advance. The communication avenues should include:

.1 Email

.2 A message shown on the login screen

.3 A banner shown to logged in users

.9 Equipment Activity Summary

.1 The user interface shall provide a filterable, single display, of all activity related to a specific piece of equipment including user changes, discarded user changes, pending alarms, discarded alarms, and acknowledged alarms for at least one year of historical data.

.2 Items shall be listed in timed order with the latest activity at the top of the list.

.3 Filters shall allow only specific activities for specific data points occurring within a specific time and date window to be displayed.

.4 It shall be possible to export a .csv copy of the currently displayed summary by clicking or tapping on the export icon.

.5 It shall be possible to create a custom trend graph containing the data shown in the currently displayed summary by tapping or clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.

.6 Clicking on the information icon in front of any displayed activity listed in the summary shall expand the display to include the name of the user, server time, value prior to the activity, the ability to annotate the activity and a user selectable icon for displaying a trend graph of the point.

.10 Equipment Relationships Summary

.1 The user interface shall provide a summary of all equipment and spaces related to the operation of the system or device currently selected for viewing.

.2 The user interface shall include the capability to navigate to the home page of any related piece of equipment or space with a single click or tap on the desired element.

.11 Equipment Data Summary

.1 The user interface shall provide a summary of all data pertaining to a particular piece of mechanical or electrical equipment in a tabular format. Clicking or tapping on any value in the summary shall display a related command panel allowing the user to command, override, or change service condition of the point selected and to annotate such actions for future reference.

.2 It shall be possible to export a .pdf copy of the report with a single click on the associated export icon.

.12 Equipment Serving Space Summary

.1 The user interface shall provide a summary of all mechanical and electrical equipment as defined in the points list that serves a selected space from the navigation tree.

.2 The summary shall be capable of including a subset of the viewable points for each system representing the key elements of interest to operators without subjecting them to long lists of points irrelevant to basic operation.

.3 Clicking or tapping on any item in the summary shall navigate to the item’s assigned home page in the user interface.

.4 It shall be possible to view a custom trend of information contained in the summary with a single click of the trend icon residing in the title header.

.5 It shall be possible to display specific systems and points by filtering equipment types desired.

.6 Because the data is intended to be a snapshot of the current conditions in the space it shall not dynamically update but a click or tap on the update icon at any time performs that function.

.13 Potential Problem Areas

.1 The user interface shall provide a summary of all points in the system related to the space that are not operating correctly (e.g. alarm, off normal or not communicating correctly) in order to provide the operator with a quick update on current conditions.

.2 The information shall include:

.1 Point status (via color)

.2 Point name

.3 Value of the point when the summary was taken

.4 Equipment that contains the offending point

.5 Space that is served by that equipment

.3 Data points in the summary may be filtered by one or more types of off-normal condition (e.g. above setpoint, offline and overridden).

.4 The summary may be exported in .csv format for inclusion in spreadsheets or other documents.

.14 Equipment Summary

.1 The user interface shall provide a summary that allows the user to compare all similar equipment that serves the space as well as downstream (child) spaces in order to evaluate conditions quickly and determine patterns for troubleshooting purposes.

.2 Each unique equipment type shall be selectable and display a representative set of values along with the space(s) being served by the device. Equipment types can be selected from a dropdown menu in the summary.

.3 Clicking or tapping on a selected device in the summary shall navigate to the home page for that piece of equipment while clicking or tapping a data point shall display the command panel for that point.

.4 It shall be possible to export a .pdf copy of the currently displayed summary by clicking or tapping on the export icon.

.5 It shall be possible to create a custom trend graph containing the data shown in the currently displayed summary by clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.

.15 User Defined Summaries

.1 Provide the capability to view, command, and modify large quantities of similar data in summaries without the use of a secondary application (e.g. a spreadsheet). These summaries shall be generated automatically, or user defined. User defined summaries shall allow up to seven user defined columns describing attributes to be displayed including custom column labels with up to 100 rows per summary.

.16 Trend

.1 The user interface shall provide the capability to view historical trend data from multiple pieces of equipment in both bar and line formats.

.2 The user shall have the ability to navigate to a selection list of frequently viewed trends.

.3 Trend graphs shall have to ability to be smartly auto generated based on equipment and space relationships.

.4 The user shall have the ability to view up to 3 graphs in a single screen and select which data points to plot on each to help with readability.

.5 Each graph shall include a dedicated selection icon to export a copy of the graphic and data in .pdf format or the data only as a .csv file.

.6 Trend graphs shall allow the plotting of non-trended point's default values.

.7 The user shall have the ability to add any trended to point a custom trend graph.

.8 The user shall have the ability to save trend graphs for reference later.

.9 The user shall be able to specify the duration of time and aggregation period for each trend line.

.10 The user shall have the ability to decide whether to show raw or aggregate trend data.

.17 Operator Access

.1 The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign “inherited” space permissions and the ability to assign user’s space-based access in bulk.

.2 The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign “inherited” space permissions and the ability to assign user’s space-based access in bulk.

.18 Graphics

.1 The user interface shall display an equipment visualization or graphic within the context of its associated space (building, floor, room, etc.) or equipment dashboard.

.2 Graphics shall be using the MS Visio program.

.3 Graphics to be same standard as existing BAS graphics of the Region, using existing library symbols which will be given by region.

.4 Graphics shall include the ability to define individual information layers for operator selection in order to clarify systems status and simplify operation on mobile devices. Where desired a master layer may be defined to include important information about the facility on all graphic screens.

.5 Graphics shall support the use of photo-realistic symbols as well as color change and animation to match the status of the related system control point.

.6 It shall be possible to export a time stamped .pdf file of the graphic being viewed in order to communicate the current conditions in the space or the equipment being viewed and to provide a historic record.

.7 An integral graphic manager shall be provided including the following features and capabilities:

.1 Creation and modification of graphics from any HTML5 capable browser without the need for additional plug-ins or software packages.

.2 Access to a full suite of pre-defined templates for air and water sourced HVAC applications as well as the ability to add custom templates as created for other use. Pre-aliased graphic templates may be defined and saved for repetitive representations of common mechanical and electrical equipment.

.3 A full suite of pre-defined three-dimensional symbols for mechanical and electrical systems as well as all line, text and shape tools required for integration into a graphic with zoom and pan capabilities on multiple platforms and in multiple browsers.

.4 The ability to search and replace items in multiple graphics with a single command.

.5 The ability to import and insert photos and images into the graphic.

.6 The ability of the graphics manager to create and edit graphics including the ability to bind graphic elements to the values and conditions of system points in both an on-line and off-line mode.

.7 The ability to create and import custom SVG symbols that can be selectable from the graphical palette and rendered at runtime.

.8 As required, the BMS Contractor shall provide software licenses in the name of the owner for programming, configuration and graphics building tools to allow designated representatives to make changes, modifications or additions to the system. While future updates or revisions may require an update fee, the owner shall incur no additional cost if they choose not to update. Systems that require any annual or time-limited licensing fees shall not be permitted.

.19 Scheduling

.1 The user interface shall provide the capability to display, in a singular view, all of the effective schedules in the context of the space (building/floor/room, etc.) or equipment that the schedule effects. The software should have the ability to display an effective schedule, for the present, or a future date.

.2 The user interface shall provide a report of all schedules affecting a space or equipment. The report shall provide the user details of events that comprise the weekly schedule and exception schedule(s). The report shall provide a means of viewing individual breakout scheduling elements for Weekly Schedule, Exceptions and Default Commands.

.3 The user interface shall provide the capability to efficiently change or modify schedules in mass quantities. This includes the capability to add, in bulk, exceptions to schedules, in addition to assigning, in bulk, weekly schedules.

.20 Command and Control

.1 It shall be possible to command system analog and binary points via a dropdown menu accessed by clicking or tapping on the value shown in any equipment summary or graphic display and completing the task in the resultant menu including an optional annotation.

.2 Commanding multiple points shall be possible on displays where multiple like system elements can be chosen.

.3 The user interface shall support users adding notes on their commands.

.4 The user interface shall support a choice of either permanent or temporary commands.

.21 Cyber Health Dashboard

.1 The Cyber Health Dashboard shall provide a centralized view of potential cybersecurity related issues or system issues, grouped into critical issues, potential risks, and informational items.

.2 The Cyber Health Dashboard shall identify user account information, including:

.1 Total number of users

.2 Dormant users

.3 Active users

.4 Locked users

.5 Temporary users

.6 Disabled users

.7 Users with Administrator role

.3 Policy related information

.1 The Cyber Health Dashboard shall indicate out-of-date software.

.2 The Cyber Health Dashboard shall identify when security certificates are set to expire.

.3 The Cyber Healthy Dashboard shall provide insight into user activity such as number of successful logins, unsuccessful logins, and locked out accounts.

.22 Involvement

.1 The user interface shall provide in a single screen, a way to visualize all interactions (I.e. - commands, writes, references) with a single object.

.2 The interface shall provide the ability to filter out any interactions (i.e. commands, writes, references) that are not pertinent.

.3 The user interface shall allow seamless navigation between one object’s Involvement view to another object’s.

.23 System-level Activity

.1 The user interface shall provide a timeline view of all audits that occur in the system, including:

.1 Logins attempts with user specified

.2 Add, delete, modification of objects

.3 Commands

.24 Search

.1 Typing a text string in the Search box shall display a list of all occurrences of that string in the mobile user interface. When a

string is represented in the description of a space or network element, selecting it shall display its default dashboard.

.2 Clicking or tapping on the Advanced Search Icon shall display the Advanced Search dialog box permitting the following:

.1 Search by Space and Equipment, Equipment Definition or Network Reference

.2 Filter the search by wildcard name or object type

.3 Multi-selection of objects for commanding or the creation of reports including Trend, Alarm, Audit and Activity for a specific period of time

.25 Offline Operation

.1 The mobile user interface shall have the ability to operate in an offline mode in order to create or edit graphics and dashboard elements.

.2 Content created offline shall be available to all authorized users for inclusion of an operating user interface later.

.26 Associated Application Components

.1 Security/Passwords

.1 Multiple-level passwords access protection shall be provided via roles and permissions. The feature will allow the system to base access on a user's job title or role and allow the user/manager access interface control, display, and database manipulation capabilities based on an assigned password.

.2 Roles may be copied and altered to meet specific roles and permissions based on the particular policies.

.3 Each user shall have the following: a user account name (with a maximum of 30 characters), a complex password or passphrase (with a min of 8 characters and a max of 50 characters), other user account policies (such as session timeout), timesheet access based on day of the week and time of day, and specific user view.

.4 The system shall allow each user to change his or her password at will.

.5 When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.

.6 A maximum of 150 categories may be used to determine or assign areas of responsibilities to each user account. A maximum of 13 (of the 150) named categories which are specifics such as “No Access, View, Advanced Review, Operate, Intervene, Diagnostic, Manage Item Events, Manage Energy, and Configure Items”.

.7 A minimum of 100 unique passwords shall be supported.

.8 Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.

.9 Operators shall be further limited to only access, command, and modify those buildings, systems, and subsystems for which they have responsibility. Provide a minimum of 100 categories of systems to which individual operators may be assigned.

.10 The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

.11 The system shall have the ability to provide a Department of Defense (DoD) specific warning banner for applicable sites that warns the user they are accessing a restricted site.

.12 After successful login to the Site Management Portal (SMP) the last time and date that user name was previously logged in is shown on the screen.

.13 Each login attempt is recorded in the system Audit Log with the option to record the IP address of the PC that made the login.

.27 Screen Manager

.1 The system will allow a customized image on the login screen (e.g. organization name, logo).

.2 User View navigations can be displayed as either a set of tabs or a drop-down list.

.3 Allows user preference for assigning of a background color for when an object is Out of Service which will enable the operator to quickly distinguish points that have been commanded to this state.

.4 The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

.28 Historical trending and data collection

.1 Each Network Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:

.1 Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:

.1 Defined time interval

.2 Upon a change of value

.2 Each Network Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

.2 Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time-scheduled basis.

.3 The system shall provide a configurable data storage subsystem for the collection of historical data. Data can be stored in SQL database format.

.4 The system shall provide data to enable optimization capabilities including fault detection and diagnostics, advanced analytics and central plant optimization without the need of a gateway or additional hardware.

.29 Database Management

.1 Where a separate SQL database is utilized for information storage the System shall provide a Database Manager that separates the database monitoring and managing functions by supporting two separate windows.

.2 Database secure access shall be accomplished using standard SQL authentication including the ability to access data for use outside of the Building Automation application.

.3 The database managing function shall include summarized information on trend, alarm, event, and audit for the following database management actions:

.1 Backup

.2 Purge

.3 Restore

.4 The Database Manager shall support four tabs:

.1 Statistics – shall display Database Server information and Trend, Alarm (Event), and Audit information on the Databases.

.2 Maintenance – shall provide an easy method of purging records from the Server trend, alarm (event), and audit databases by supporting separate screens for creating a backup prior to purging, selecting the database, and allowing for the retention of a selected number of day's data.

.3 Backup – Shall provide the means to create a database backup file and select a storage location.

.4 Restore – shall provide a restricted means of restoring a database by requiring the user to log into an Expert Mode in order to view the Restore screen.

.5 The Status Bar shall appear at the bottom of all Database Manager Tabs and shall provide information on the current database activity. The following icons shall be provided:

.1 Ready

.2 Purging Record from a 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 Starting the Device Manager

.10 Shutting down the Device Manager

.11 Action successful

.6 The Database Manager monitoring functions shall be accessed through the Monitoring Settings window and shall continuously read database information once the user has logged in.

.7 The System shall provide user notification via taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.

.8 The Monitoring Settings window shall have the following sections:

.1 General – Shall allow the user to set and review scan intervals and start times.

.2 Email – Shall allow the user to create and review e-mail and phone text messages to be delivered when a Warning or Alarm is generated.

.3 Warning – shall allow the user to define the Warning limit parameters, set the Reminder Frequency, and link the e-mail message.

.4 Alarm – shall allow the user to define the Alarm limit parameters, set the Reminder Frequency, and link the e-mail message.

.5 Database login – Shall protect the system from unauthorized database manipulation by creating a Read Access and a Write Access for each of the Trend, Alarm (Event) and Audit databases as well as an Expert Mode required to restore a database.

.9 The Monitoring Settings Taskbar shall provide the following informational icons:

.1 Normal – Indicates by color and size that all databases are within their limits.

.2 Warning – Indicates by color and size that one or more databases have exceeded their Warning limit.

.3 Alarm – Indicates by color and size that one or more databases have exceeded their Alarm limit.

.10 The System shall provide user notification via Taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.

.30 Demand Limiting and Load Rolling

.1 The System shall provide a Demand Limiting and Load Rolling program for the purpose of limiting peak energy usage and reducing overall energy consumption and shall be implemented as outlined within the sequences of operations.

.2 The System shall support both Sliding Window and Fixed Window methods of predicting demand.

.3 The System shall support three levels of sensitivity in the Sliding Window demand calculations for fine tuning the system.

.1 Low Setting – Sheds loads later and over the shortest amount of time. Maximizes the time the equipment is on.

.2 Medium Setting – Sheds loads earlier over a longer amount of time than the Low Setting. Increases the time the equipment is on and decreases the probability of exceeding the Tariff Target over the Low Setting.

.3 High Setting – Sheds loads earlier over a longer amount of time than the Medium Setting. Minimizes the probability of exceeding the Tariff Target.

.4 The System shall have both a Shed Mode and a Monitor Only Mode of operation.

.1 When the Shed Mode is engaged, the System shall actively control the Demand.

.2 When the Monitor Mode is engaged, the System will simulate the shedding action but will not take any action.

.5 The Demand Limiting program shall monitor the energy consumption rate and compare it to a user defined Tariff Target. The system shall maintain consumption below the target by selectively shedding loads based upon a user defined strategy.

.6 The Demand Limiting program shall be capable of supporting a minimum of 10 separate Load Priorities. Each load shall be user assigned to a Load Priority.

.7 The Demand Limiting program shall be capable of supporting a minimum of 12 separate Tariff Targets defining the maximum allowed average power during the current interval.

.8 The System shall support a Maximum Shed Time for each load as determined by the user. The system shall restore the load before the Maximum Shed time has expired.

.9 The System shall support a Minimum Shed Time for each load as determined by the user. The system shall not restore the load sooner than the Minimum Shed Time has expired.

.10 The System shall support a Minimum Release Time for each load as determined by the user. The System shall not shed the load until it has been off for the Minimum Release time.

.11 The System shall support three user defined options if the meter goes unreliable.

.1 Shedding – The currently shed loads will be released as their Maximum shed Times expire.

.2 Maintain the Current Shed Rate – The System will use the Demand Limiting shed rate that was present when the meter went unreliable.

.3 Use Unreliable Meter Shed Rate – the system will control to a user defined Unreliable Shed Rate target.

.12 The Load Rolling program shall sum the loads currently shed and compare it to a user defined Load Rolling Target. The system shall maintain consumption below the target by selectively shedding loads based upon a user defined Load Priority.

.13 The Load Rolling program shall be capable of supporting a minimum of 10 separate Load Priorities. Each load shall be user assigned to a Load Priority.

.14 The Load Rolling program shall be capable of supporting a minimum of 12 separate Tariff Targets defining the amount of power by which the demand must be reduced.

.15 The System shall provide the user with a Load Tab that displays all of the Demand Limiting and Load Rolling parameters for any selected load.

.16 The System shall provide the user with a Load Summary that displays all of the loads associated with the Demand Limiting and Load Rolling programs. Status Icons for each load shall indicate:

.1 Load is Offline

.2 Load is Disabled

.3 Load is Shed

.4 Load is Locked

.5 Load is in Comfort Override

.17 The Load Summary shall include a Load Summary Runtime view listing the following load conditions:

.1 Load Priority

.2 Shed Strategy

.3 Load Rating

.4 Present Value

.5 Ineligibility Status

.6 Active Timer

.7 Time Remaining

.8 Last Shed Time

.18 Provide Site Management Portal with associated user interface at each Network Engine as well as all Application and Data Servers.

2.6 Network Control Engines

.1 General

.1 The Network Control Engine shall be a fully user-programmable, supervisory controller. The Network Control Engine shall monitor the network of equipment controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Engines.

.2 Provide a 250Va UPS for the Supervisory Network Controller.

.3 The Network Control Engine shall also be a fully user-programmable, equipment controller that includes a minimum of 28 I/O points.

.4 Automation Network – The Network Control Engine(s) shall reside on the automation network and shall support a subnet system controllers.

.5 User Interface – Each Network Control Engine shall have the ability to deliver a web-based User Interface previously described. All computers connected physically or virtually to the automation network shall have access to the web-based user interface.

.6 Processor – The Network Control Engine(s) shall be microprocessor-based with a minimum word size of 32 bits. The Network Control Engine shall be a multi-tasking, multi-user, and real-time digital control process. Standard operating systems shall be employed. Network Control Engine(s) size and capability shall be sufficient to fully meet the requirements of this Specification.

.7 Memory – Each Network Control Engine shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

.8 Secure Boot – The Network Control Engine shall prevent malicious or unauthorized software applications from loading during the system startup process.

.9 User Authentication – The Network Control Engine shall support local user authentication.

.10 Password Security – Access to the Network Control Engines' embedded user interface shall require a password of 8 to 50 characters including a minimum of one lower case letter, one upper case letter, one number, and one special character. An alarm shall be generated after three unsuccessful attempts within 15 minutes and the user shall be denied access until permission is renewed by a system administrator.

.11 Network Security – Communication between the Network Control Engine and other system networked devices including additional Network Engines, Application and Data Servers, Open Data Servers (BACnet listed OWS), and user interface clients shall be encrypted and support HTTPS with Transport Level Security (TLS) Version 1.2. Self-signed certificates are to be provided with the option of configuring trusted certificates.

.12 Hardware Real Time Clock – The Network Control Engine shall include an integrated, hardware-based, real-time clock, with a supercapacitor to maintain time for a minimum of 72 hours during a power loss. Controllers using a battery to maintain time during a power loss shall not be acceptable.

.13 Diagnostics – The Network Control Engine(s) shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Control Engine(s) shall provide both local and remote annunciation of any detected component failures or repeated failures to establish communication.

.14 Power Failure – In the event of the loss of normal power, the Network Control Engine(s) shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

.15 During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.

.16 Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

.17 Certification – The Network Control Engine(s) shall meet and be listed to the UL 916 Standard for Energy Management Equipment and be FCC Compliant to CFR47, Part 15, Subpart B, Class A.

.18 Device Integration – The Network Control Engine(s) shall support integrating and supervising networked devices using the following communication protocols on the device/controller network:

.19 The Network Control Engine(s) shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135 on the controller network.

.1 The Network Control Engine(s) shall support Remote Field Bus integration via a BACnet IP to MS/TP router.

.2 The Network Control Engine(s) shall be tested and BTL listed/certified as a BACnet Building Controller (B-BC).

.3 A BACnet Protocol Implementation Conformance Statement shall be provided for the Network Engine(s).

.4 The Protocol Implementation Conformance Statement shall be submitted 10 days prior to bidding.

.20 The Network Control Engine(s) shall support Johnson Controls N2 or third party N2 Open devices.

.21 The Network Engine(s) shall optionally support integration of networked devices using the following networking protocols:

.1 MODBUS RTU

.2 MODBUS TCP

.3 KNX – KNC is an open communication standard (EN 50090, ISO/IEC 14543) that many European manufacturers have applied to lighting controls, blinds and shutters, HVAC controls, security systems, energy management, audio, video, displays, and remote controls.

.4 M-Bus – M-Bus (Meter Bus) is a European standard (EN 1434-3) that applies primarily to energy and heat meters.

.5 C-CURE 9000 Access Control System

.6 victor Video Management System

.7 OPC UA

.22 The Network Control Engine shall employ a finite state programming to eliminate unnecessary conflicts between control

functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

.23 The Network Control Engine shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only, shall not be acceptable.

.24 The Network Control Engine shall support the following types of inputs and outputs:

.25 Universal Inputs – shall be configured to monitor any of the following:

.1 Analog Input, Voltage Mode

.2 Analog Input, Current Mode

.3 Analog Input, Resistive Mode

.4 Binary Input, Dry Contact Maintained Mode

.5 Binary Input, Pulse Counter Mode

.26 Binary Inputs – shall be configured to monitor either of the following:

.1 Dry Contact Maintained Mode

.2 Pulse Counter Mode

.27 Analog Outputs – shall be configured to output either of the following:

.1 Analog Output, Voltage Mode

.2 Analog Output, Current Mode

.28 Binary Outputs – shall output the following:

.1 24 VAC Triac

.29 Configurable Outputs – shall be configured to output either of the following:

.1 Analog Output, Voltage Mode

.2 Binary Output, 24 VAC Triac Mode

.30 The Network Control Engine shall have the ability to monitor and control a network of sensors and actuators over a Sensor Actuator (SA) Bus.

.31 The SA Bus shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135.

.32 The SA Bus shall support a minimum of 9 devices.

.33 The SA Bus shall operate at a maximum distance of 1,200 Ft. between the Network Control Engine and the furthest connected device.

.34 The Network Control Engine shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the Field Bus or the SA Bus.

.35 The Network Control Engine shall provide removable, labeled, screw terminal blocks for 24 VAC power, communication bus and I/O point field wiring.

.36 The Network Control Engine shall include the following multi-color, flashing LEDs to indicate important operating conditions and status.

.37 Heartbeat – to indicate each of the following states: operational (normal), powered but not operational, starting up, shutting down, or no power applied

.38 Fault – to indicate if fault conditions have been detected

.39 SA Bus – to indicate if communication is occurring on the SA Bus

.40 FC BUS-1 – to indicate if communication is occurring on FC Bus port 1

.41 Ethernet Activity - to indicate if Ethernet Traffic is occurring or not occurring

.42 USB-1|2 – to indicate if a supported device is connected, no device is connected, or an unsupported device is connected on USB port 1 or 2

.43 FC EOL - to indicate if the end-of-line termination switch is on or off

.44 Communications Ports – The Network Control Engine(s) shall provide the following ports for connecting networkable devices:

.45 Two (2) USB ports

.1 One (1) RS-485 port

.2 Two (2) Ethernet ports

.2 Network Control Engine – Flexible Sizing Options

.1 The Network Control Engine shall support up to 4 or 50 supervised devices across all supported integrations.

.2 Provide Johnson Controls SNCxxxxx-04x, -0x or approved alternate as indicated on plans.

2.7 Application and Data Server

.1 Application and Data Server (ADS)

.1 This site shall be connected to the Owner's existing BAS server.

.2 The Application and Data Server shall be a software solution designed to manage the collection and presentation of large amounts of trend data, event messages, operator transactions, and system configuration data on the BMS.

.3 The Application and Data Server shall act as site director for consolidating BMS information from Network Engines for integrated storage and presentation. The ADS shall not restrict access to the individual Network Engines ensuring optimal BMS accessibility in the event of individual component failure or a loss of communication.

.4 The Application and Data Server shall act as a server for the following functionality as described in these specifications:

.1 Mobile user interface providing user friendly access to system information via site navigation by place or device.

.2 Site Management Portal functions and applications.

.3 System Configuration Tool controller configuration and programming.

.5 Network Security – Communication between the Network Engines, Application and Data Server, and user interface clients shall be encrypted and support HTTPS with Transport Level Security (TLS) Version 1.2. Self-signed certificates are to be provided with the option of configuring trusted certificates.

2.8 DDC Equipment Controllers

.1 General Purpose Equipment Controller

.1 The General Purpose Equipment Controller (CGM) shall be a fully programmable, digital controller that communicates via the BACnet MS/TP protocol.

.2 The CGM shall support BACnet Standard ANSI/ASHRAE 135.

.3 The CGM shall be BTL listed/certified.

.4 The CGM shall be tested and certified as a BACnet Advanced Application Controller (B-AAC).

.5 A BACnet Protocol Implementation Conformance Statement shall be provided for the CGM.

.6 The Conformance Statement shall be submitted 10 days prior to bidding.

.7 The CGM shall employ finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

.8 CGM controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

.9 The CGM shall be assembled in a plastic housing with protection class IP20 (IEC529) and flammability rated to UL94-5VB.

.10 The CGM shall include an integral real-time clock and support time-based tasks which enables these field controllers to monitor and control:

.1 Schedules

.1 Calendars

.2 Alarms

.3 Trends

.11 The CGM can continue time-based monitoring when offline for extended periods of time from a network.

.12 The CGM can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.

.13 The CGM shall include troubleshooting LEDs to indicate the following conditions:

.1 Power—to indicate if the controller is powered or not powered

.2 Fault – to indicate if the controller is in its default state, has no faults, has a device fault, is in startup or download mode, or has an SA Bus communication issue

.3 SA Bus – to indicate if SA Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

.4 FC Bus – to indicate if FC Bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

.5 EOL – to indicate if the end-of-line termination switch is on or off

.14 The CGM shall have the ability to transfer and apply firmware files to all SA Bus devices (XPM, IOM, and NS8000) connected to it.

.15 The CGM shall include pluggable and labeled screw terminal blocks for all I/O, FC and SA Bus communication, and power wiring connections.

.16 The CGM shall accommodate the direct wiring of analog and binary I/O field points with the following resolution.

.17 Inputs – 24-bit analog-to-digital converter

.18 Outputs – +/- 200 mV accuracy in 0-10 VDC applications

.19 The CGM shall support the following types of inputs and outputs supplied in the amounts required for the specified applications:

.20 Universal Inputs – shall be configurable to monitor any of the following:

.1 0-10 VDC analog input

.2 4-20 mA analog input

.3 0-600k ohms analog input

.4 Dry contact binary input

.21 Binary Inputs – shall be configurable to monitor either of the following:

.1 Dry Contact Maintained Mode

.2 Pulse Counter Mode

.22 Analog Outputs – shall be configurable to output either of the following:

.1 0-10 VDC analog output

.2 4-20 mA analog output

.23 Binary Outputs – shall output the following:

.1 24 VAC Triac

.24 Configurable Outputs – shall be capable of the following:

.1 0-10 VDC analog output

.2 24 VAC Triac binary output

.25 The CGM shall have the ability to reside on a Field Controller Bus (FC Bus).

.26 The FC Bus shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135.

.27 The FC Bus shall support communications between the CGMs and the Network Engine.

.28 The FC Bus shall also support peer-to-peer communications between non-supervisory devices, allowing these devices to communicate system data with each other directly, bypassing the supervisory network engine on the bus.

.29 The FC Bus shall support a minimum of 100 equipment controllers and/or expansion modules in any combination.

.30 The FC Bus shall operate at a maximum distance of 15,000 Ft. between the CGM and the furthest connected device.

.31 The CGM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.

.32 The CGM shall have the ability to monitor and control a network of sensors and actuators over a SA Bus.

.33 The SA Bus shall be a MS/TP Bus supporting BACnet Standard Protocol SSPC-135.

.34 The CGM shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over a MS/TP Bus.

.35 Provide Johnson Controls CGM or approved equal as shown on plans.

.2 XPM expansion I/O module (XPM)

.1 The XPM provides additional input and output interfaces for use in digital controllers.

.2 The XPM shall communicate with controllers over the FC Bus or the SA Bus.

.3 The XPM shall support BACnet Standard ANSI/ASHRAE 135.

.4 The XPM shall be BTL listed/certified and carry the BTL Label.

.5 The XPM shall be tested and certified as a BACnet Smart Actuator (B-SA).

.6 A BACnet Protocol Implementation Conformance Statement shall be provided for the XPM.

.7 The Conformance Statement shall be submitted 10 days prior to bidding.

.8 The XPM shall include pluggable screw terminal blocks for all I/O, SA/FC bus communication, and power wiring connections.

.9 The XPM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.

.10 The XPM shall accommodate the direct wiring of analog and binary I/O field points with the following resolution:

.1 Inputs – 24-bit analog-to-digital converter

.2 Outputs – +/- 200 mV accuracy in 0-10 VDC applications

.11 The XPM shall support the following types of inputs and outputs:

.1 Universal Inputs – shall be configured to monitor any of the following:

.1 0-10 VDC analog input

.2 4-20 mA analog input

.3 0-600k ohms analog input

.4 Dry contact binary input

.2 Binary Inputs – shall be configured to monitor either of the following:

.1 Dry Contact Maintained Mode

.2 Pulse Counter Mode

.3 Analog Outputs – shall be configured to output either of the following:

.1 0-10 VDC analog output

.2 4-20 mA analog output

.4 Binary Outputs – shall output the following:

.1 24 VAC Triac

.5 Configurable Outputs – shall be capable of the following:

.1 0-10 VDC analog output

.2 24 VAC Triac binary output

.12 The XPM shall include troubleshooting LEDs to indicate the following conditions:

.1 Power – to indicate if the device is powered or not powered

.2 Fault – to indicate if the device is in its default state, has no faults, has a device fault, is in startup or download mode, or has an SA Bus communication issue

.3 SA/FC Bus – to indicate if bus communication is occurring and normal, is not occurring, or was occurring but has been lost and is waiting to rejoin

.4 EOL – to indicate if the end of line termination is on or off.

.13 Provide Johnson Controls XPM or approved alternate as shown on plans.

2.9 Network Sensors

.1 The Network Sensors (NS) shall have the ability to monitor the following variables all within a single wall-mounted enclosure (no exceptions) as

required by the systems sequence of operations and as specified on drawings:

.1 Zone Temperature

.2 Zone Humidity

.3 Zone Occupancy

.4 Zone CO_2

.2 The NS shall transmit the information back to the controller on the SA Bus using BACnet Standard protocol SSPC-135.

.3 The NS shall be BTL listed/certified and carry the BTL Label.

.4 The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).

.5 The Network Zone Temperature Sensors shall not include any display or setpoint adjustment

2.10 Actuators and Operators

.1 Actuators shall be electronic, as detailed in the following sections.

.2 The manufacturer shall be ISO 9001 certified.

.3 Electronic Damper Actuators

.1 Spring Return Actuators shall comply with the following regulatory agency listings: cULus, CSA C22.2 No24-93, and CE marked.

.2 Spring Return Actuators shall be of direct-coupled design and require no crank arm or linkage for mounting to a shaft.

.3 Spring Return Actuators shall offer a coupling method which requires a toothed V-bolt clamp and nuts with toothed cradle.

.4 Spring Return Actuators shall be configured for reversible mounting which provides either clockwise or counter clockwise operation.

.5 Spring Return Actuators power failure operation shall configure upon a loss of electric power to the actuator, a mechanical spring return system shall drive the actuator to the failsafe home position. Other forms of internal energy storage for power failure operation shall not be acceptable.

.6 Spring Return Actuators shall utilize the following motor technology:

.1 Modulating types: Microprocessor-controlled brushless DC motors

.2 On/Off types: DC brush motor

.7 Spring Return Actuators shall be furnished with Electronic Stall Detection which protects the actuator from overload at all angles of rotation without the need for end switches.

.8 Spring Return Actuators shall comply with enclosure ratings of NEMA type 2 or IP54 mounted in any orientation.

.9 Spring Return Actuators shall eliminate the need for electrical ground wires for double-insulated construction.

.10 Spring Return Actuators shall be sized for the torque required to seal the damper at load conditions.

2.11 Control Valves

.1 Ball Valves, 1/2 through 2 in.

.1 Ball Valves shall have forged brass bodies.

.2 Valves shall have available either Chrome Plated Brass Balls or 300 Series Stainless Steel Balls in all sizes.

.3 Valves shall have available either Nickel Plated Brass Stems or 300 Series Stainless Steel Stems with a blow-out proof stem design in all sizes.

.4 Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.

.5 Stem seals shall be double EPDM O-rings.

.6 Flow Characterization Disk shall be manufactured from Amodel AS-1145HS Polyphthalamide Resin and rated for 50 psi maximum differential pressure and shall be inserted against the casting of the valve.

.7 All ball valves with internal pipe thread end connections shall be rated to 580 psi maximum static pressure at 203°F (95°C) fluid temperature.

.8 All ball valves with sweat end connections or press end connection shall be rated to 300 psig maximum static pressure at 203°F (95°C) fluid temperature.

.9 All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.

.10 Ball Valves with stainless steel balls and stems shall be rated for use with 15 psig saturated steam.

.11 Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.

.12 Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.

.13 Valves shall be maintenance free.

.14 Valves shall be provided with a 5 year equipment warranty starting from date of Substantial Performance.

.15 Valves shall be rated for 200 psi differential closeoff pressure.

.16 Valve actuators shall be UL-recognized or CSA-certified.

.2 Ball Valves, 2 ½ .in through 4 in. Flanged

.1 Ball valves shall have forged brass bodies with ASME Class 150 ductile iron flanges.

.2 Valves shall be manufactured from 300 series stainless steel balls and the flanges shall rotate independently until tightened down which is an advantage during installation.

.3 Valves shall have 300 series steel stems with a blow-out proof stem design.

.4 Stem seals shall have double EPDM O-rings.

.5 Valves have graphite reinforced PTFE seats with EPDM O-ring backing.

.6 Flow characterization disk shall be manufactured from Amodel AS-1145HS Polypthalamide Resin or approved alternate, and rated for 50 psid maximum differential pressure.

.7 Flow characteristics shall be of equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.

.8 Valves shall be rated for service with hot water, chilled water and 50% glycol solutions and are rated for use with 25 psig (kPa) saturated steam.

.9 Two-way valves shall be rated for 100 psid close off pressure and three-way valves shall be rated for maximum of 50 psid close off pressure.

.10 Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.

.11 Valves shall be maintenance free.

.12 Valves shall be provided with a 5 year warranty.

.13 Valves shall be CE marked and in compliance with essential requirements and other relevant provisions of the Pressure Equipment Directive (PED).

2.12 Sensors and Transmitters

.1 Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements. Exact OEM equivalents of specified sensors and transmitters shall be acceptable if clearly identified in submittals.

.2 Temperature Sensors

.1 Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.

.2 The temperature sensor shall be of the resistance type, and shall be two-wire 1000 ohm nickel RTD

.3 The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion.

	Point Type	Accuracy
.2	Chilled Water	+ .5°F
.3	Room Temp	+ .5°F

.4 Duct Temperature + .5°F

.5 All Others + .75°F

.3 Thermowells

.1 Thermowell manufacturer shall have models available in stainless steel, brass body, and copper bulb.

.2 When thermowells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and sensor.

.3 Thermowells shall be pressure rated and constructed in accordance with the system working pressure.

.4 Thermowells and sensors shall be mounted in a direct mount (no adapter) offering faster installation or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.

.5 Thermowells constructed of 316 stainless steel shall comply with Canadian Registration Number (CRN) pressure vessel rating.

.4 Outside Air Sensors

.1 Provide outside air sensor for this project.

.2 Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall be provided with a solar shield.

.3 Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.

.4 Temperature transmitters shall be of NEMA 3R (IP54) or NEMA 4 (IP65) construction and rated for ambient temperatures.

.5 The outdoor sensor shall be capable of being mounted on a roof, pole or side of a building utilizing its preassembled mounting bracket.

.6 Outside air relative humidity sensors 0-100% full range of accurate measurement. Operating temperature -4 to 140°F (-20 to 60°C).

.7 Outside air temperature sensors operating temperature range -40 to 140°F,

.8 +/- .55°F (+/- .3°C).

.5 Duct Mount Sensors

.1 Duct mount sensors shall mount in an electrical box through a hole in the duct, positioned to provide ease of accessibility for repair or replacement.

.2 Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

.3 For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be provided.

.6 Averaging Sensors

.1 For ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

.2 For plenum applications, such as mixed air temperature measurements, a continuous averaging sensor or a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.

.3 Capillary supports at the sides of the duct shall be provided to support the sensing string.

.7 Humidity Sensors

.1 The sensor shall be a solid-state type, relative humidity sensor of the Thin Film Capacitance or Bulk Polymer Design. The sensor element shall resist service contamination.

.2 The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.

.3 The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH at 77°F unless specified elsewhere.

.4 Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R (IP54) or NEMA 4 (IP65) enclosure with sealtite fittings.

.5 A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.

.6 Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

.8 Carbon Dioxide Sensor

.1 Silicon based sensor with dual wavelength infrared tunable interference filters. Measurement stability of +/-100ppm over 5 years.

.2 For duct mounted units provide adjustable probe depth, output transmitter and relay. Airflow range: 0 to 7,500 ft/Minute (o to 2,286 m/Minute)

.3 For wall mounted units provide

.4 Operating temperature range: 23 to 113°F (-5 to 45°C)

.5 Transmitter output signal: Jumper Selectable: 0 to 20 mA or 4 to 20 mA or 0 to 10 VDC (Default), Maximum Output Current: 25 mA; Maximum Output Voltage: 12.5 V Maximum 30 V, 0.5A, Class

.6 Measuring range: 0 to 2000 ppm CO_2

.7 Accuracy at 25ºC: < ±[30 ppm CO_2 + 2.0% of reading] (includes manufacturing deviation and drift). All accuracy specifications reflect testing the transmitters using high-grade, certified gases. Transmitters are intended for an altitude range of 0 to 1,969 ft (0 to 600 m) above sea level without compensation.

.9 Differential Pressure Transmitters

.1 General Air and Water Pressure Transmitter Requirements:

.2 Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

.3 Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

.4 Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.

.5 A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

.6 Low Differential Water Pressure Applications (0” - 20” WC):

.1 The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.

.2 The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

.3 .01-20” WC input differential pressure range

.4 4-20 mA output

.5 Maintain accuracy up to 20 to 1 ratio turndown

.6 Reference Accuracy: +0.2% of full span

.7 Medium to High Differential Water Pressure Applications (Over 21” WC):

.1 The differential pressure transmitter shall meet the low-pressure transmitter specifications with the following exceptions:

.2 Differential pressure range 10” WC to 300 PSI

.3 Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability)

.4 Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

.8 Building Differential Air Pressure Applications (-1” to +1” WC):

.1 The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response

to variation of differential pressure or air pressure sensing points.

.2 The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

.3 -1.00 to +1.00 WC input differential pressure ranges. (Select range appropriate for system application)

.4 4-20 mA output

.5 Maintain accuracy up to 20 to 1 ratio turndown

.6 Reference Accuracy: +0.2% of full span

.9 Low Differential Air Pressure Applications (0” to 2.5” WC):

.1 The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

.2 The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications.

.3 (0.00 - 1.00” to 5.00”) WC input differential pressure ranges (select range appropriate for system application)

.4 4-20 mA, 0-5 VDC, 0-10 VDC output

.5 Maintain accuracy up to 20/1 ratio turndown

.6 Reference Accuracy: +0.25%, or 0.5% of full span

.10 Medium Differential Air Pressure Applications (5” to 21” WC):

.1 The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements.

.2 Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability

.3 Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 psig.)

.4 Thermal Effects: <+.033 F.S./Deg. F. over 40°F to 100°F (calibrated at 70°F.)

.5 Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

3 Execution

3.1 BAS specific requirements

.1 Graphic Displays

.1 Provide a colour graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

.2 User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

.2 Provide custom reports as required for this project.

.3 Actuation / Control Type

.1 Primary Equipment

.1 Controls shall be provided by equipment manufacturer as specified herein.

.2 All damper and valve actuation shall be electric.

.2 Air Handling Equipment

.1 All air handlers shall be controlled with a HVAC-DDC Controller.

.2 All damper and valve actuation shall be electric.

.3 Terminal Equipment:

.1 Terminal Units (VAV, Chilled beam, FC, etc.) shall have electric damper and valve actuation.

.2 All Terminal Units shall be controlled with HVAC-DDC Controller).

3.2 Installation practices

.1 BMS Specific Requirements

.1 Graphic Displays

.1 Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

.2 User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

.2 Custom Reports:

.1 Provide custom reports as required for this project.

.3 Actuation / Control Type

.1 Primary Equipment

.2 Controls shall be provided by equipment manufacturer as specified herein.

.3 All damper and valve actuation shall be electric.

.4 Air Handling Equipment

.1 All air handlers shall be controlled with a HVAC-DDC Controller.

.2 All damper and valve actuation shall be electric.

b. Terminal Equipment:

.3 Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.

.4 All Terminal Units shall be controlled with HVAC-DDC Controller.

.2 Installation Practices

.1 BMS Wiring

.1 All conduit, wiring, accessories and wiring connections required for the installation of the BMS, as herein specified, shall be provided by the BMS Contractor unless specifically

shown on the Electrical Drawings under Division 24 Electrical. All wiring shall comply with the requirements of applicable portions of Division 24 and all local and national electric codes, unless specified otherwise in this section.

.2 All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.

.3 The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BMS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BMS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

.4 Class 2 Wiring

.1 All Class 2 (24 VAC or less) wiring shall be installed in conduit unless otherwise specified.

.2 Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5’ from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.

.5 Class 2 signal wiring and 24 VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

.6 Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

.2 BMS Line Voltage Power Source

.1 120-volt AC circuits used for the BMS shall be taken from panel boards and circuit breakers provided by Division 26.

.2 Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

.3 DDC terminal unit controllers may use AC power from motor power circuits.

.3 BMS Raceway

.1 All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2”.

.2 Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.

.3 All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

.4 Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

.5 Controls contractor shall provide raceways of CO/NO2 detectors to control panels.

.4 BMS Identification Standards

.1 Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

.2 Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

.5 BMS Panel Installation

.1 The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer’s recommendations.

.2 The BMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

.3 Input Devices

.1 All Input devices shall be installed per the manufacturer recommendation.

.2 Locate components of the BMS in accessible local control panels wherever possible.

.4 HVAC Input Devices – General

.1 All Input devices shall be installed per the manufacturer recommendation.

.2 Locate components of the BMS in accessible local control panels wherever possible.

.3 The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.

.4 Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

.5 Outside Air Sensors

.1 Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outdoor air conditions accurately.

.2 Sensors shall be installed with a rain proof, perforated cover.

.6 Building Differential Air Pressure Applications (-0.5” to +0.5” WC)

.1 Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.

.2 The interior tip shall be inconspicuous and located as shown on the drawings.

.7 Duct Temperature Sensors

.1 Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

.2 The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.

.3 For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

.4 The sensor shall be mounted to suitable supports using factory approved element holders.

.8 Space Sensors

.1 Shall be mounted per ADA requirements.

.2 Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

.9 Low Temperature Limit Switches

.1 Install on the discharge side of the first water or steam coil in the air stream.

.2 Mount element horizontally across duct in a serpentine pattern ensuring each square foot of coil is protected by 1 foot of sensor.

.3 For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

.10 Air Differential Pressure Status Switches

.1 Install with static pressure tips, tubing, fittings, and air filter.

.11 Water Differential Pressure Status Switches

.1 Install with shut off valves for isolation.

.5 HVAC Output Devices

.1 All output devices shall be installed per the manufacturers' recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.

.2 Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

.3 Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.

.4 Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.

.5 Electronic Signal Isolation Transducers: Whenever an analog output signal from the BMS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems.

3.3 Training

.1 The BMS contractor shall provide the following training services:

.1 Four hours of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.4 Commissioning Requirements

.1 Fully commission all aspects of the BMS work.

.2 Acceptance Check Sheet

.1 Prepare a check sheet that includes all points for all functions of the BMS as indicated on the point list included in this specification.

.2 Submit the check sheet to the Engineer for approval.

.3 The Engineer will use the check sheet as the basis for acceptance with the BMS Contractor.

End of section

1 General

1.1 Section includes

.1 Control sequences of operation.

1.2 Related requirements

.1 Comply with the General Requirements of Section 20 01 00 and the Common Work Elements of Section 20 05 00.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Prior to submittal, controls sequences are to be reviewed by Engineer of Record / Project Engineer for approval.

.3 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

2 Products – not used

3 Execution

3.1 Sequence of operation

.1 Exhaust Fans

.1 Occupancy Controlled and Temperature Controlled

.1 EF-1

.1 On a need for ventilation based on detection of occupancy in the room, the motorized damper (MD-1) shall open, and the fan shall operate at low speed as defined in the Fan Schedule on the drawings. The fan shall remain at low speed until the signal from occupancy sensor is removed.

.2 On a need for ventilation based on the signal from the room temperature sensor, the motorized damper (MD-1) shall open, and the fan shall operate at high speed as defined in the Fan Schedule on the drawings. Fan shall be energized at a space temperature of 32 °C (90 °F), adjustable and de-energized at 28 °C (82 °F), adjustable. Room temperature sensor shall be connected to the BAS.

.3 Status:

.1 Room temp

.2 Fan status

.4 Alarms:

.1 Room temp above 35 °C (adjustable).

.2 Interlocked with the space lighting

.1 EF-3, 4, 5, 6, 7 & 8

.1 Fan shall be interlocked with the space lighting by Division 26.

.2 De-Stratification Fans

.1 Install all control wiring between the fans and the SmartSense controllers. Mount the temperature sensors on the roof structure in accordance with the manufacturer’s instructions.

.3 DOAS-1 Air Handling Unit

.1 General

.1 Occupied versus unoccupied mode shall be determined by a time of day schedule as determined by the BAS and shall be adjustable.

.2 Unoccupied Administration areas

.1 Monday to Friday 18:00 to 07:00

.2 Saturday, Sunday and Holidays

.3 Occupied Administration areas

.1 Monday to Friday 07:00 to 18:00

.4 EMS areas

.1 Occupied 24/7

.2 Upon initial start-up, start both supply and exhaust fans. Provide a signal to both fans for control of fan speed.

.3 Open the outdoor air damper, the sanitary return (MD-3) and (MD-5) and the general return (MD-4) air dampers. Provide each damper with a modulating damper actuator.

.1 Provide modulating damper actuators for control of all unit mounted control dampers.

.4 Provide sensors as required to provide the following information to the BAS:

.1 Outdoor air temperature, relative humidity and CO2

.2 Return air temperature, relative humidity and CO2

.3 Supply air discharge air temperature & relative humidity

.4 Exhaust air discharge air temperatureEnergy Recovery Wheel leaving air temperature

.5 Differential pressure across each filter bank

.6 Differential pressure across Energy Recovery Wheel

.7 Supply and return temperatures at the heating and cooling coils

.5 Control three-way heating and cooling coil control valves in response to discharge air conditions. All supply air temperature setpoints shall be adjustable:

.1 Heating:

.1 Occupied = 21 °C (70 °F)

.2 Cooling:

.1 Occupied = 24 °C (75 °F)

.6 Relative humidity setpoints shall be adjustable:

.1 Administration areas where the room thermostats are equipped with integrated relative humidity sensor (referring drawings M300 and M300.01):

.2 Winter:

.1 Occupied = 40% (± 10%)

.3 Summer:

.1 Occupied = 50% (± 10%)

.4 Humidifier shall stop operation if:

.1 Humidistat setpoints of rooms are satisfied, or

.2 Duct mounted High Humidity Switch in DOAS supply air duct is activated.

.7 Provide control of the unit Energy Recovery wheel and defrost.

.8 Provide building differential pressure sensor as shown on floor plan. Adjust the speed of supply fan control to duct static pressure.Exhaust fan shall modulate to maintain building pressure.

.9 Unit Operation:

.1 The unit provides ventilation air to the fan coils located throughout the building.

.2 Primary air delivery to the terminal units is controlled by local VAV boxes, and DOAS-1 air volume responds to the changing duct system static pressure and adjusts to match the system needs. Provide a duct mounted static pressure sensor to monitor the system pressure and control unit response. Approximate location of duct mounted static pressure sensor is shown on drawing.

.3 Airflow measuring station shall be provided for the DOAS unit supply air fan. Exhaust air fan shall follow the supply air fan speed and also adjust to the value of building differential pressure sensor.

.10 System must include controls that automatically reset the supply-air temperature in response to outdoor air temperature.

.11 Motorized Dampers (MD-3), (MD-4) and (MD-5):

.1 Sanitary exhaust and general return from the spaces is controlled by three (3) modulating control dampers which respond to Occupancy status, and Time-of-Day schedule.

.2 When EMS is the only occupied space of the building (as determined by the time-of-day scheduling) general return air damper (MD-4) shall be closed and washroom exhaust air damper (MD-5) shall be fully open).

.3 When the entire space of Phase-1 building is occupied (as determined by the zone occupancy sensors and time-of-day scheduling) dampers (MD-3) and (MD-5) shall be fully open and damper (MD-4) shall only open to allow a maximum airflow rate of 885 CFM (417 LPS).

.4 At completion of phase 2, when the building is entirely occupied (as determined by the zone occupancy sensors and time-of-day scheduling) all three dampers shall be fully open and damper (MD-4) shall allow a maximum airflow rate of 1175 CFM (555 LPS).

.12 At the end of Phase-1, balance the speed of supply and return fan to deliver 1755 CFM (830 LPS) to the VAV boxes of Phase-1. At the end of Phase-2 balance the speed of supply and return fan to deliver 2050 CFM (967 LPS) as shown on equipment schedule on drawings.

.13 Status:

.1 All fans

.2 All damper positions

.3 All control valve positions

.14 Alarms:

.1 Program alarms for each temperature, humidity and CO2 setpoint. Verify operating conditions during commissioning and consult with the engineer for alarm values.

.2 Should the relative humidity of any space not be maintained for 2 hours in winter during occupied hours, an alarm shall be initiated.

.3 CO2 values measured from indoor spaces shall be continuously compared to the CO2 values of outdoor air. The setpoint shall be 400 ppm, and DOAS unit shall provide additional amount of outdoor air only if it improves the indoor air quality. Alarm shall be initiated if the indoor air quality is beyond CO2 concentration of 700 ppm for a pre-determined period of time. All set points shall be adjustable.

.4 Alarm all fan status conditions.

.4 ERV-1 Rooftop unit

.1 ERV-1 provides ventilation to the Vehicle Garage.

.2 The system is operated at low speed on a continuous basis. Supply fan airflow shall be 602 LPS (1275 CFM) and exhaust fan airflow shall be 661 LPS (1400 CFM) to maintain negative pressure in the Vehicle Garage.

.3 Measure levels of Nitrogen Dioxide and Carbon Monoxide at locations shown on the drawings, and should levels exceed any of the setpoints, the system shall be activated to high speed. Where supply fan airflow shall be 1203 LPS (2550 CFM) and exhaust fan airflow shall be 1321 LPS (2800 CFM) to maintain negative pressure in the Vehicle Garage.

.4 Upon initial start-up, start both supply and exhaust fans. Provide a signal to both fans for control of fan speed.

.5 Open the dampers. Provide on/off damper actuators for control of all unit mounted control dampers.

.6 Provide sensors as required to provide the following information to the BAS:

.1 Outdoor air temperature

.2 Return air temperature

.3 Supply air discharge air temperature

.4 Exhaust air discharge air temperature

.5 Differential pressure across each filter bank

.6 Energy Recovery Wheel leaving air temperature

.7 Differential pressure across Energy Recovery Wheel

.8 Supply and return temperatures at the heating coil

.7 Control the heating coil control valve in response to discharge air conditions and the wall mounted occupancy sensor. All temperature setpoints shall be adjustable:

.1 Heating:

.1 Unoccupied = 15.5 °C (60 °F) (setback)

.2 Occupied = 20 °C (68 °F)

.8 Provide control of the unit Energy Recovery wheel and defrost.

.9 Airflow measuring station shall be provided for the ERV unit supply air fan. Exhaust air fan shall follow the supply air fan speed and provide 10% additional airflow to maintain negative pressure in respect to the adjacent rooms.

.10 Status:

.1 All fans

.2 All damper positions

.3 All control valve positions

.11 Alarms:

.1 High level of Nitrogen Dioxide and Carbon Monoxide

.2 Program alarms for each temperature setpoint. Verify operating conditions during commissioning and consult with the engineer for alarm values.

.3 Alarm all fan status conditions.

.5 Horizontal Fan Coil Units and VAV boxes

.1 General

.1 Occupied versus unoccupied modes of all fan coils shall be determined by a time of day schedule as determined by the BAS and shall be adjustable.

.2 Unoccupied Administration areas

.1 Monday to Friday 18:00 to 07:00

.2 Saturday, Sunday and Holidays

.3 Occupied Administration areas

.1 Monday to Friday 07:00 to 18:00

.4 EMS areas

.1 Occupied 24/7

.5 Outdoor air supply to the fan coil units is controlled by local VAV boxes. The VAV boxes are controlled from local occupancy sensors and from BAS Time-of-Day schedule and are modulated when the space is occupied.

.6 Occupied versus unoccupied modes of following fan coils and VAV boxes shall be determined by time-of-day schedule. Dampers of VAV boxes shall modulate to

minimum damper position to shut off the outdoor airflow in unoccupied mode:

.1 FC-1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 17, 18 & 19 and associated VAV boxes

.7 During scheduled occupied hours, occupied versus unoccupied modes of following fan coils and VAV boxes shall also be determined by occupancy sensors integrated with the room thermostats. Dampers of VAV boxes shall modulate to minimum damper position to shut off the outdoor airflow in unoccupied mode:

.1 FC-10, 11, 15 and 16 and associated VAV boxes

.8 All room temperature setpoints shall be adjustable:

.1 Heating:

.1 Unoccupied = 20 °C (68 °F) (setback)

.2 Occupied = 22.2 °C (72 °F)

.2 Cooling:

.1 Unoccupied = 26.6 °C (80 °F) (setup)

.2 Occupied = 24 °C (75 °F)

.9 Fans shall have high/medium/low airflow connections for field wiring by the Controls contractor via dry contact terminals. Fan speed shall switch between high/medium/low airflow rates based on the signal from thermostat and CO2 sensor.

.2 Unoccupied

.1 The fan shall be off. A request for either heating or cooling shall enable the fan.

.2 The heating and cooling control valves shall be in the closed position.

.3 Upon a request for heating, the cooling control valve shall remain in the closed position and the heating control valve shall modulate to maintain the space setback temperature.

.4 Upon a request for cooling, the heating control valve shall remain in the closed position and the cooling control valve shall modulate to maintain the space setup temperature.

.3 Occupied

.1 The fan shall be on.

.2 The heating and cooling control valves shall be in the closed position.

.3 Upon a request for heating, the cooling control valve shall remain in the closed position and the heating control valve shall modulate to maintain the space setpoint temperature.

.4 Upon a request for cooling, the heating control valve shall remain in the closed position and the cooling control valve shall modulate to maintain the space setpoint temperature.

.4 Emergency Operations Center

.1 Referring to instructions from the Region of Durham, Emergency Operations rooms 202 and 203 will not be occupied simultaneously with the Classrooms 112 and 113 (because of the emergency situation). In order to avoid oversizing the DOAS unit, VAV boxes of these two areas shall not be at fully open position at the same time. Therefore, if occupancy sensors of either of the rooms 202 or 203 show occupancy for longer than 10 minutes (adjustable, to confirm an Emergency situation) VAV boxes of Classrooms 112 and 113 shall override the BAS pre-determined schedule and revert to unoccupied mode.

.5 Maximum heating ΔT between supply air temperature and space temperature shall be limited to 11 °C (20 °F). Maximum cooling ΔT between supply air temperature and space temperature shall be limited to 9 °C (16 °F).

.6 Alarms shall be generated by the BAS for the following:

.1 Fan off when commanded on.

.2 Fan on when commanded off.

.3 Space temperature greater than 6 °C (10.8 °F) beyond setpoint.

.4 Filter requires replacement.

.6 Heat Pumps and Electric Boiler

.1 Equipment selection includes:

.1 Hardwired safeties and interlocks

.2 The set point for chilled water system is 6.6 °C (44 °F) supply water temperature. The set point for the heating water system is 48.9 °C (120 °F) supply water temperature.

.3 Heat pumps HP-1 to HP-2 are to be energized if either the loop water supply temperature (LWST) for the heating loop is below set point or the LWST for the cooling loop is above setpoint for 10 minutes (adjustable).

.1 HP-1 is to be energized if there is a call for heating or cooling. The second stage of heating would be HP-2, which shall energize if the loop temperature setpoint has not been reached within 10 minutes (adjustable), and the two units shall run in parallel.

.2 Each heat pump shall have external control valves to control flow to the supply fluid inlet, controlled by the BAS.

.3 During normal mode: the control valve shall be fully opened. The heat pump shall provide a 0-10V signal to the BAS. The control valve shall modulate position based on the internal heat pump controller logic, to monitor the refrigerant pressure, compressor operation and heat pump safeties.

.4 During emergency mode, the control valve shall override the 0-10V signal from the heat pump, to drive the control valve to a minimum position. Control valve position to be determined during balancing.

.4 Provide sensors for supply and return water temperature and glycol temperatures at the heat pumps.

.5 Interface with the heat pump controllers to provide the system status, control, and alarm conditions and values to the BAS.

.6 Emergency Heating Modes:

.1 If heat pumps are working, and the heating water supply fluid temperature cannot be maintained within the limits defined in item 2 for 10 minutes, adjustable, then start the electric boiler and pump P-9 to maintain heating water setpoint.

.2 If P-1A or P-1B are out of service, or if P-2 or P-3 are out of service, or if HP-1 or HP-2 are out of service:

.1 Start the electric boiler and pump P-9 as required to maintain heating water setpoint.

.2 If the electric boiler is on, and the heating water supply fluid temperature cannot be maintained within the limits defined in item 2, then the occupancy status of all fan coil zones shall be adjusted to unoccupied mode.

.7 Pumps

.1 Provide status condition for all pumps.

.2 A lead point shall determine the lead pump for each A&B pair. The pump shall be alternated on a 200 hour basis (adjustable).

.3 Monitor supply and return water temperatures and glycol temperatures from the systems serving:

.1 Geothermal field

.2 HP-1 & HP-2

.3 DOAS-1

.4 ERV-1

.5 Electric boiler

.6 Fan coils

.7 In-floor heating

.8 Heat Exchanger HX-1

.4 P-1A&B (duty/duty): Geothermal field circulators are energized when the signal from temperature sensors on P-6, P-7 or P-8 loops is beyond the setpoint.

.5 Primary pumps P-1A&B shall be controlled based on the temperature sensors on the supply and return of the primary GHX loop. Pumps shall run at min. 30% between a set dead band of 10 °C (50 °F) in heating and 23.8 °C (75 °F) in cooling. Primary pumps P-1A&B shall not run unless Secondary pumps P-2 or P-3 are running.

.6 When the outdoor air temperature drops below 15.6 °C (60 °F) setpoint, adjustable, the heating water system is enabled. When the system is enabled, the BAS shall start pumps P-2, P-5A (or B) and

operate the pump(s) continually until the heating water system is disabled by outdoor temperatures.

.7 P-3: This pump is energized by the BAS to operate when the heat pump HP-2 is enabled.

.8 P-7A&B and P-8: When the hot water heating system is enabled, the BAS shall activate the listed pumps. The pump speed is modulated in response to the specific system operating pressure measured remotely from the pump.

.9 When the outdoor air temperature rises above 26.6 °C (80 °F) setpoint, the chilled water system is enabled. When the system is enabled, the BAS shall start pumps P-2, P-4A (or B) and operate the pump(s) continually until the chilled water system is disabled by outdoor temperatures.

.10 P-6A&B (duty/duty): When the chilled water system is enabled, the BAS shall activate pumps P-6A (or B). The pump speed is modulated in response to the specific system operating pressure measured remotely from the pump.

.11 Pumps P-4A&B (duty/duty) and P-6A&B (duty/duty) are to be energized upon a call for cooling. P-4A&B will operate at constant speed and P-6A&B will operate at variable speed based on loop pressure.

.12 Pumps P-5A&B (duty/duty) and P-7A&B (duty/duty) are to be energized upon a call for heating. P-5A&B will operate at variable speed and P-7A&B will operate at variable speed based on loop pressure.

.13 Primary pumps P-4A&B and P-5A&B shall not run unless Secondary pumps P-6A&B or P-7A&B or P-8 are running and there is demand for load in the building.

.14 P-6A&B and P-7A&B: Provide minimum flow bypass at the farthest point from the Mechanical room.

.15 P-9: This pump is energized by the BAS to operate when the electric boiler is enabled.

.8 Heat Exchanger

.1 Modulate 2-way control valve on the hot side piping of the heat exchangers to maintain the cold side supply water temperatures.

.2 Provide temperature sensors for supply and return water and glycol temperatures on both hot and cold sides of the exchangers.

.9 Split System Air Conditioner

.1 Complete all control wiring between the indoor evaporators and the associated outdoor condensing unit.

.2 Connect to the system controller and monitor a common system alarm from each individual system.

.3 Provide a BAS room temperature sensor.

.10 Radiant In-floor heating

.1 Operate the individual manifold control valves in response to space temperatures and in-slab temperature sensors, to prevent over-heating.

.11 Hot water Unit heater

.1 Provide a remote thermostat and control the unit heater fan and 2-way control valve to maintain space temperature.

.12 Forced Flow heaters

.1 Provide integrated thermostats and control the forced flow heater fan and 2-way control valves to maintain space temperature.

.13 Electric Snow melting system

.1 Monitor the status and alarms of the snow melt system as specified in specification 23 83 13.

.14 Heating and Cooling of Electrical Room

.1 Provide a BAS room temperature sensor.

.2 Heating

.1 Upon a request for heating, the FC-20 fan shall be enabled. The cooling control valve shall remain in the closed position and the heating control valve shall modulate to maintain the space setpoint temperature.

.2 Fan and control valves shall be energized at a space temperature of 18 °C (64.4 °F), adjustable.

.3 Cooling

.1 Upon a request for cooling, the FC-20 fan shall be enabled. The heating control valve shall remain in the closed position and the cooling control valve shall modulate to maintain the space setpoint temperature.

.2 Fan and control valves shall be energized at a space temperature of 31 °C (88 °F), adjustable.

.3 Based on the signal from the room temperature sensor (upon a request for additional cooling, or if chilled water is not available), the motorized damper (MD-2) shall open and EF-2 exhaust fan shall be energized to maintain the space setpoint temperature.

.4 Exhaust fan shall be energized at a space temperature of 36 °C (97 °F), adjustable and de-energized at 33 °C (91.5 °F), adjustable.

.5 Status:

.1 Room temp

.2 Exhaust fan status

.4 Alarms shall be generated by the BAS for the following:

.1 Space temperature above 38 °C (100 °F), or below 10 °C (50 °F), adjustable.

.2 Fan coil filter requires replacement.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

.2 The requirements of this Section shall apply to and govern the work of this Division and shall be read as an integral part of each Section.

.3 The Electrical Drawings and these Specifications are complementary to each other and each forms a part of this contract. In the event of discrepancies between Drawings and Specifications, the more restrictive conditions shall apply unless a written clarification is obtained from the Consultant.

.4 Misinterpretation of any requirement of the Drawings or Specifications will not relieve this Division of responsibility to complete the work. If in doubt, contact the Consultant for written clarification. If clarification is not sought the Consultant's decision shall be final and binding on the Contractor.

.5 Do not scale drawings but use only dimensions, which are shown. Where exact building dimensions and details are required, use only figured dimensions on the Architectural or Structural Drawings or job site dimensions.

.6 No deviations from the Drawings or Specifications will be permitted without written authorization from the Consultant.

.7 Make, at no additional cost, any changes or additions to materials and/or equipment necessary to accommodate structural conditions (runs around beams, columns, etc.).

1.2 Related requirements

.1 Provide all labour, tools, services and installation (except as noted below) of all products.

1.3 Relationship to other divisions

.1 Division 26 shall:

.1 Provide line voltage power wiring and terminations to equipment of all Divisions.

.2 Provide low voltage (31 to 750 volts) control and interlock wiring to equipment of all other Divisions, unless otherwise indicated on the electrical drawings.

.3 Division 22/23/25 control and interlock wiring, extra-low (up to & including 30 volts) and/or low voltage shall be by Division 22/23/25.

.4 Provide 0-10 V dimming and all related BAS lighting controls wiring.

.5 Provide junction box with control transformer and 120V/1/60 control power wiring and terminations at BAS integrated and/or interfaced mechanical equipment.

.6 Provide junction box with control transformer and 120V/1/60 control power wiring and terminations motorized doors, windows and miscellaneous BAS integrated building equipment.

.7 Provide concealed junction boxes at BAS interfaced door and window contacts.

.8 Provide conduit with fish-wire from all BAS interfaced equipment to BAS unit. BAS control wiring 24Vac shall be by Division 22/23/25.

.9 Provide DOL starters, soft-starters, variable frequency drives and disconnect switches as noted on drawings, unless already included in the scope of Division 26 supply as unit mounted or packaged equipment. Refer to mechanical-electrical coordination schedule.

.2 Division 22, 23 and/or 25 shall:

.1 Complete related control and interlock wiring, extra-low (up to & including 30 volts) and/or low voltage (31 to 120 volts) unless otherwise indicated.

.2 Provide all air handling units, gas fired unit heaters, fans, pumps, motors & domestic water heaters where indicated complete with control panels, starters and/or disconnect switches. Refer to mechanical-electrical coordination schedule.

.3 Provide, mount and wire all thermostats (and guard where indicated) and low voltage control transformer for mechanical equipment as noted.

.4 Provide, mount and wire all damper motors.

.5 Provide variable frequency drives for unit mount and packaged mechanical equipment as required.

.6 Mount and wire duct thermostats to control the heating and/or cooling in the HVAC systems.

.7 Provide extra low voltage wiring (up to 30 Vac) for BAS integrated/interfaced equipment.

1.4 Scope

.1 Generally, the work includes, in the time frame set out or implied, the provision of a complete, interfaced, reliable, continuous operating electrical systems shown, implied, described or required, including but not limited to all labour, equipment, confirmations, co-ordination of equipment, interim set-up and operation, spare parts, fees, service layouts, permits, inspections, investigations, studies, acceptance tests, including 3rd party, demonstrations, reports, bonds, notices, declarations, administration, liaison, reviews, meetings, correspondence and travel. Provide training, warranties and insurance.

.2 Refer to Division 1 for requirements regarding temporary power.

.3 The electrical drawings are schematic and indicate major equipment and intended overall arrangement. Exact sizes, dimensions, locations, devices and arrangements shall suit equipment, site conditions and requirements. Review shop drawings for sizes and requirements under Division 26 and ensure compatibility of all systems specified and installed; report problems, concerns and variations. The Engineer shall review shop drawings of equipment prior to installation. Refer to Division 1.

.4 The Contract Drawings and the Specifications are to be read in conjunction with all other design and engineering documents. Provide all equipment after co-ordinating and reviewing all Division 26 work required by other Sections, service companies and jurisdictional authorities. The omission of work and materials that are required to complete the project is not to be interpreted as relieving this Section of the necessity of providing such work and materials. Ensure all equipment is installed correctly and sequentially.

.5 In case of conflict among authorities, trades, drawings, specifications and other documents, the most stringent requirements shall apply, as directed by the Consultant.

.6 All work and material shall be installed to the manufacturer's and the Consultant's recommendations and satisfaction, as applicable. Construction shall be performed by relevant, competent, qualified and certified trade persons.

.7 Protect materials and equipment after delivery to minimize the probability of condensation or other damage prior to the application of final heating systems.

1.5 Permits and allowances

.1 The Consultant has submitted the Contract Drawings and specifications to the Electrical Safety Authority for approval (if required). ESA comments will be incorporated in the project using normal contract procedures. Co-ordinate and provide additional information as required. Inform the Engineer of any concerns noted prior to ordering equipment.

.2 Pay all Electrical Safety Authority permit and inspection costs.

.3 Co-ordinate with Supply Authority and provide additional information as required.

.4 Provide, in a timely manner, a copy of all applicable comments made by authorities having jurisdiction.

1.6 Examinations

.1 Prior to submission of tender, carefully examine the electrical drawings, drawings of other trades and all Specifications having a bearing on the work of this Division. Visit the site of the work and thoroughly ascertain that the work of this Division can be carried out satisfactorily without any changes to the Drawings or Specifications. No extras will be allowed for anything, which would have been revealed in the course of such an examination.

.2 Examine the proposed locations of equipment and fixtures of other trades and report any defects or interference with the work of this Division in writing to the Consultant. Affected work shall not commence until any discrepancies adversely affecting the work of this Division are remedied.

.3 Fully understand the function of the systems described in this Division. Have no doubt as to the extent of the systems and/or materials and labour

required. Contact the Consultant for clarification. No extras will be allowed to complete systems inadequately installed or not fully operational.

1.7 Extras and credits

.1 Changes to the contract requiring additions to or deletions from the work of this Division shall be carried out upon written request of the Consultant. Extras to the contract or credits shall be submitted with a complete cost breakdown as follows:

.1 Materials, quantities and unit prices for all equipment required or deleted.

.2 Unit man hours.

.3 Total material cost.

.4 Total man hours.

.5 Hourly rate. (Refer to Supplementary Conditions and General Contract).

.6 Total overhead and profit. (Refer to Supplementary Conditions and General Contract).

.2 Equipment and material costs shall be accepted at net costs only.

.3 Invoices, time sheets, and other evidence of costs shall be provided upon request by the Consultant.

.4 Prices not submitted in this format will not be accepted.

1.8 Regulations

.1 Comply with the latest Ontario Building Code and amendments and the requirements of the Municipal Building Department.

.2 Comply with the latest regulations of the Electrical Safety Code and the requirements of the local Electric Safety Authority inspection department, the requirements of the local hydro commission, the recommended standards of the Canadian Standards Association, the Ontario Ministry of Labour, the Occupational Health and Safety Act, Provincial and Federal governments or any other authority having jurisdiction.

.3 The Contract Drawings show the minimum standard acceptable regardless of any lesser standards set by any Codes, Regulations or Authorities Having Jurisdiction.

1.9 Interruption of services

.1 To obtain permission for an interruption of electrical services, submit a request at least two weeks prior, stating the time the interruption is to begin, expected duration and the services and area affected. Interruption of services shall not proceed without approval of Consultant.

.2 Where in the opinion of the Consultant it is advisable or desirable to maintain service in the area or any part of the area involved during the interruption, provide such temporary wiring, equipment, etc., as required or as may be deemed necessary by the Consultant to maintain services. No additional payments will be made for any additional cost or inconveniences which may incur.

.3 Under no circumstances will the Contractor's operation be allowed to interfere with or interrupt the Owner’s use of the building.

1.10 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit a list of delivery dates for each type of equipment, within 30 days of awarding of the contract or at the preconstruction meeting. The list shall include the manufacturer's name. Shop drawings shall indicate conformity with all items of the equipment specifications.

.4 Submit to Consultant submittals listed for review. Submit with reasonable promptness and in an orderly sequence so as to not cause delay in the construction schedule. Failure to submit in ample time is not considered sufficient reason for an extension of Contract Time and no claim for extension by reason of such default is allowed.

.5 Work affected by the submittal not to proceed until the review is complete unless an approval is obtained from the Consultant.

.6 Review submittals prior to submission to the Consultant. This review represents that necessary requirements have been determined and verified, and that each submittal has been checked and co-ordinated with the requirements of the Contract Documents.

1.11 Shop drawings

.1 Submit shop drawings in accordance with the General Requirements of Division 1 and as required in various sections of these specifications and on the drawings.

.2 Shop drawings to be submitted with a cover sheet(s) on the Contractor's letterhead listing the following information:

.1 Project:

.2 Owner/Client:

.3 Architect:

.4 Electrical Consultant:

.5 General Contractor:

.6 Electrical Contractor:

.7 Supplier

.8 Specification Section

.9 Materials or Equipment submitted

Note: Include space for review stamps by Consultant, General Contractor and Electrical Contractor.

.3 Prepare and submit for review, where specified, shown or considered necessary by the Consultant, shop drawings showing details of work as follows:

.1 Descriptive names of equipment (as identified on drawings), manufacturer’s model numbers and electrical characteristics.

.2 Physical dimensions of equipment.

.3 Sections, arrangements and details which indicate complete construction as well as interconnections with other work.

.4 Location and type of anchors and fastenings.

.5 Materials including gauges, thickness, sizes and finishes.

.4 Manufacturer's printed data sheets for standard items are acceptable providing pertinent characteristics are identified and relate to specified items. Submit eight (8) copies of data sheets except where specified otherwise.

.5 Check shop drawings and data sheets, before submission as follows:

.1 Against contract documents and other applicable shop drawings, to ensure that work adjacent to and affecting other work is accurately detailed.

.2 To ensure that work shown on shop drawings conforms to requirements of Contract Documents.

.3 Enclose notice in writing of any variations from requirements of Contract Documents.

.6 Indicate on shop drawings that they have been checked by applying stamp "checked and certified correct for construction", including date and Contractor's signature. Drawings and details submitted without such stamp or whenever it is evident that drawings have not been checked (despite approval stamp) will not be reviewed and will be returned to Contractor.

.7 The Consultant's review of shop drawings and data sheets pertain to general design only. Errors in dimensions, quantities or interference will be marked if noticed, but this will not in any way relieve Contractor from his responsibility to complete work as shown and specified.

.8 Shop drawings are to be returned with "Reviewed – No Comment", "Reviewed – As Noted", "Reviewed – Revise and Resubmit" or “Review by Consultant Not Required”.

.1 "Reviewed – No Comment" - Drawings conform with the general design concept.

.2 "Reviewed – As Noted" - Drawings conform with the general design concept subject to the corrections noted. Drawings to be corrected and resubmitted for final review and incorporation into maintenance manuals. Such submission is not to hold up manufacture.

.3 "Reviewed – Revise and Resubmit" - Drawings are rejected and manufacture/supply of this equipment is not to proceed. Drawings are to be resubmitted with required corrections on equipment.

.4 “Review by Consultant Not Required”.

1.12 Certificates

.1 Provide copies of all required certificates of approval, test results and verifications. Insert in Operating and Maintenance Manuals.

1.13 Record drawings

.1 As-built drawings are to be maintained in accordance with the general requirements of Section 01 78 00 - Closeout Submittals.

.2 The Consultant shall provide the Contractor with an extra set of white prints on which to show clearly in red ink, as the job progresses, all changes and deviations from the plans, including all changes as part of change orders, site instructions or site condition.

.3 Dimension all buried services/wiring from permanent structures.

.4 Maintain as-built drawings on site for periodic review by Consultant.

.5 On application for Certificate Of Substantial Performance, provide to the Consultant two complete sets of as-built drawings.

1.14 Warranty

.1 Provide warranty of material and workmanship in accordance with the requirements of Division 1.

.2 Provide manufacturers' standard warranty if greater than one (1) year.

.3 The Contractor is to submit extended warranties for specific materials and/or work where specified. Extended warranties are to be issued on the Contractor's letterhead, under seal, and issued in the name of the Owner.

.4 Insert warranties in Operating and Maintenance Manuals.

1.15 Operating & maintenance manuals

.1 Refer to Section 01 78 00 – Closeout Submittals.

.2 Provide operating instructions. Operating instructions to include:

.1 General description of each electrical system.

.2 Step by step procedure to follow in commissioning each piece of equipment.

.3 Schematic control diagrams for each separate system.

.4 Drawings of each control panel identifying all components on the panels and their function.

.5 All electrical equipment wiring diagrams.

.3 Provide maintenance instructions. Maintenance instructions are to include:

.1 Manufacturer's maintenance instructions for each item of electrical equipment installed under this Division. Instructions are to include installation instructions, parts numbers and lists, name of supplier and maintenance instructions.

.2 Summary list of each item of electrical equipment requiring maintenance, indicating the name of the equipment item, maintenance required and frequency of maintenance.

.4 Provide written warranty (or warranties as applicable) on the Contractor's letterhead addressed to the Owner, copied to the General Contractor.

.5 Include certificates issued by regulatory authorities (ESA, etc.), test and/or verification reports, programming parameters for devices with field adjustment capabilities and a list of ranges and setpoints at final commissioning.

1.16 Spare parts

.1 Provide three (3) spare indicating light bulbs of each type used.

.2 Provide two spare ballasts of each type used.

.3 Provide four spare lamps of each type used.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 All material shall be specification grade, where applicable, new and carry CSA approval or special approval in accordance with ESA requirements.

.2 Similar devices and items shall be from one (1) manufacturer throughout the project.

.3 Material or equipment specified by technical description shall be provided with the best commercial qualities obtainable for the purposes described.

.4 Requests for extra money, time or equipment substitution due to late ordering of equipment will not receive any consideration.

2.3 Alternate materials

.1 Provide proposed alternate materials to those specified in accordance with Section 01 25 00 - Substitution Procedures.

2.4 Electric motors, equipment & controls

.1 Verify installation and co-ordination responsibilities related to motors, equipment and controls, as indicated.

.2 Control wiring, conduit and connections: provided by Division 26 where voltage exceeds 30 V, provided by Division 15 where voltage is 30 V or less.

2.5 Equipment identification

.1 Identify all switchboards, panel(s), starter(s), disconnect switch(es), etc. with approved, mechanically fastened lamacoid nameplates. Indicate equipment being controlled, voltage and the supply panel/device and its location.

.2 Labels on fused disconnect switches to include size and type of fusing. Also indicate "Equipment to be off before Isolation".

.3 Terminal cabinets, junction boxes and pull boxes: indicate system and voltage and/or circuits.

.4 Use 3 mm (1/8 in.) thick lamacoid plates. White colour background with 6 mm (1/4 in.) high black letters. Use client equipment numbers as required.

.5 Within panel boards, provide a typewritten directory of all circuits identifying the loads connected.

.6 Provide warning signs, as specified or to meet requirements of Inspection Department and Consultant. Use porcelain enamel for outdoor and decal for indoor signs, minimum 175 x 250 mm size.

2.6 Conduit & cable identification

.1 Colour code conduits, metal sheathed cables and junction boxes. Code with plastic tape or paint at points where conduit or cable enters wall, ceiling or floor and at 3,050 mm (120 in.) intervals. Colours to be 25 mm (1 in.) wide as follows:

.1 Fire Alarm, Red

.2 Telephone, Green

.3 Emergency Power, Blue

2.7 Wiring identification

.1 All wiring shall be colour coded and shall be identified at each end with Brady self-sticking permacode wire markers. Update and or indicate numbers on "as-built drawings".

.2 Maintain phase sequence and colour coding throughout. Colour coding to CSA C22.1.

.3 Use colour coded wires in communication cables, matched throughout system.

3 Execution

3.1 Equipment installation

.1 Do complete installation in accordance with CSA C22.1 except where specified otherwise.

.2 Do overhead and underground systems in accordance with CSA C22.3 No.1 except where specified otherwise.

.3 The location of any panels, equipment, outlet, raceway and wiring may be changed by the Consultant if the new location is within a limit of 3,000 mm

(120 in.) radius of the original location. Provide changes without extra cost if requested before installation.

.4 Do not install wall-mounted equipment at locations where built-in furniture or other equipment is to be installed. In cases of conflict, install equipment above the built-in furniture and clear the trim by approximately 150 mm (6 in.) unless otherwise instructed by the Consultant.

.5 Arrange for openings in the walls and floors for transportation and installation equipment. Extra charges for cutting and making good of walls or floors for the work will not be accepted.

.6 Prior to installation and start up, co-ordinate and confirm that all electrical equipment and systems are compatible, are sized correctly and shall work safely as intended.

.7 Provide an acceptable documented procedure for the commissioning of all systems. Contact the Consultant to arrange for a viewing of the system demonstration. All systems shall be fully operational and verification documents available at least twenty (24) hours before requesting a review by the Consultant. Provide hard copies of all programs for review before and after commissioning of equipment. At the discretion of the Owner, back charges for costs incurred may be levied if systems are not commissioned and operational at the time of the Consultants visit and return visit(s) are required.

.8 Install, program, set-up and adjust all equipment as indicated and or required and complete all commissioning.

.9 Electrical work is indicated generally on the Contract Drawings by standard symbols as per the legend. The letters in the symbol indicate the type of device as per the schedules. The letters and numbers outside and adjacent to the symbols indicate the panel and circuit number. If no circuit identification is indicated utilize available circuit(s) and load to acceptable practices.

.10 All row mounted fixtures shall be accurately installed in line with all mounting hardware.

.11 Support every outlet box, junction box, panel tub, etc. independent of conduits running to it.

.12 Surface mounted distribution and control equipment shall be mounted square and level on flame retardant backboard.

.13 Transformers, switchboards and motor control centres shall be mounted on housekeeping pads.

.14 Mount exit lights at a level so that they are clearly visible and to the satisfaction of authorities having jurisdiction.

3.2 Nameplates & labels

.1 Ensure manufacturer's nameplates, CSA labels and identification nameplates are visible and legible after equipment is installed.

3.3 Conduit & cable installation

.1 Install conduit and sleeves prior to pouring of concrete.

.2 Sleeves through concrete: schedule 40 steel pipe, sized for free passage of conduit, and protruding 50 mm (2 in.). All holes through concrete or steel structural members shall be approved by the Structural Consultant.

.3 Install cables, conduits and fittings close to building structure so furring can be kept to minimum.

3.4 Equipment mounting heights

.1 Mounting height of equipment is from finished floor to centreline of equipment unless indicated otherwise. Verify unspecified heights and dimensioned locations before installation. Ensure indicated heights are per current Barrier Free access requirements before installation. Stagger back to back devices (such that they are not located in a common stud wall cavity) to reduce sound transfer and maintain fire separations.

.2 Install switches, receptacles, devices, etc. on one common centre line when shown on the drawings in a grouping.

.3 The top of recessed boxes to be mounted even with the nearest top of block. Alternatively, the bottom of recessed boxes may be mounted even with the nearest bottom of block.

.4 Generally, install electrical equipment at following heights unless indicated otherwise on drawings:

.1 Digital light switches and thermostats in public spaces: 1,200 mm (47 in.).

.2 Pit light switches: 305 mm (12 in.) below hatch, right side (preferred).

.3 Wall receptacles:

.1 General: 405 mm (16 in.).

.2 Height above top of counters or counter splash backs: 175 mm (7 in.).

.3 Mounted high (refrigerator, etc.): 1,120 mm, (44 in.).

.4 In mechanical rooms: 1,120 mm (44 in.).

.4 Panelboards: as required by Code or as indicated (Maximum circuit breaker height 1,700 mm (67 in.)).

.5 Exit lights at ceiling height, to a maximum of 2,290 mm (90 in.). Confirm visibility before installation.

.6 Wall mounted emergency lights: 2,440 mm (96 in.).

.7 Handicap door release/opener button & washroom lights: 1,016 mm (40 in.) refer to latest Region of Durham standards.

.8 Motor starters, generally: 1,400 mm (55 in.).

.9 Telephone outlets: 400 mm (16 in.).

.10 Wall mounted telephone outlets: as noted on drawings.

.11 Television outlets: as noted on drawings.

.12 Hand dryers: 1,200 mm (47 in.).

3.5 Clean-up

.1 Continuously remove surplus and waste material generated by the electrical work.

.2 Clean all supplied equipment and material of dirt, dust and stray paint, immediately prior to final acceptance of the work.

.3 Remove tools, surplus material, scrap and debris (resulting from the work of this Division) on completion of the Contract.

.4 Clean and touch-up surfaces of shop-painted equipment scratched or marred during shipment or installation, to match original paint.

.5 Clean, prime and paint exposed non-galvanized hangers, racks and fastenings to prevent corrosion.

3.6 Co-ordination of protective devices

.1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings.

.2 Refer to Arc Flash Risk Assessment Section 26 05 73 – Arc Flash Risk Assessment for further details.

.3 Verify device settings prior to energizing circuits.

3.7 Testing

.1 Furnish labour, materials, and instruments and bear other costs in connection with all tests, including third party and factory tests, obtain required certificates of approval, acceptance, and compliance with regulations of agencies having jurisdiction and as specified.

.2 Confirm proper operation of each piece of equipment and system for correct function.

.3 Measure amperage readings of each phase at service entrance switchboard and on each panel/equipment feeder. Ensure phase imbalance does not exceed 10 % at operating load conditions. Adjust loads as required.

.4 Megger test all feeders prior to energizing; submit test results in Operating & Maintenance Manuals. Provide insulation resistance testing on service entrance cables, panel feeders and feeders to major equipment. Testing to be completed as follows:

.1 Megger circuits, feeders and equipment up to 350 V with a 500 V instrument.

.2 Megger 350-600 V circuits, feeders and equipment with a 1000 V instrument.

Note: Check resistance to ground and conductor to conductor resistance for conductors in the same conduit before energizing.

.5 Measure voltage at service entrance switchboard, at feeder supply connections and at load connections. Measurements to be taken under

normal operating conditions. Submit test results in Operating & Maintenance Manuals.

.6 Confirm continuity of metal raceways where raceway is used in lieu of a bonding conductor.

.7 Demonstrate that the settings described in the co-ordination study have been incorporated.

3.8 Inspections

.1 Inform the Consultant in writing a minimum of three (3) working days prior to any test of any system.

.2 All work and materials covered by these Specifications shall be subject to inspection at any time by the Consultant.

.3 If the Consultant finds that any material or workmanship does not conform to these specifications undertake to correct such workmanship within five (5) days of notification by the Consultant.

.4 Work shall not be deemed complete and Certificate of Substantial Performance will not be issued, until all indicated certificates of approval, test results and/or verifications have been delivered to the Consultant.

.5 Notify the Consultant when the final inspection of the work shall be performed. Defects or deficiencies found during this inspection shall be corrected to the satisfaction of the Consultant before final payment is made.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

.2 Wiring and equipment as detailed on the Contract drawings and specified herein.

1.2 Related requirements

.1 Section 26 05 00 – General Electrical Requirements

.2 Durham Cable Specification

1.3 References

.1	CSA C22.2 No. 41	Grounding and Bonding Equipment
.2	CSA C22.2 No. 38	Thermoset Insulated Wires and Cables.
.3	CSA C22.2 No. 51	Armoured Cables.
.4	CSA C22.2 No. 52	Underground Secondary and Service-Entrance Cables.
.5	CSA C22.2 No. 75	Thermoplastic-Insulated Wires and Cables.
.6	CSA C22.2 No. 83.1	Electrical Metallic Tubing - Steel.
.7	CSA C22.2 No. 211.1	Rigid Types EB1 and DB2/ES2 PVC Conduit.
.8	CSA C22.2 No. 211.2	Rigid PVC Conduit.
.9	CSA C22.2 No. 45.1	Electrical Rigid Metal Conduit – Steel
.10	CSA C22.2 No. 45.2	Electrical Rigid Metal Conduit – Aluminium, Red Brass & Stainless Steel
.11	CSA C22.2 No. 56	Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit
.12	CSA C68.3	Power Cables with Thermoset Insulation.
.13	CSA C22.2 No. 85	Rigid PVC Boxes and Fittings.
.14	CSA C22.2 No. 18.1	Metallic Outlet Boxes
.15	CSA C22.2 No. 18.2	Non-Metallic Outlet Boxes

.16	CSA C22.2 No. 18.3	Conduit, Tubing and Cable Fittings
.17	CSA C22.2 No. 18.4	Hardware for the Support of Conduit, Tubing and Cable
.18	CSA C22.2 No. 40	Cutout, Junction and Pull Boxes.
.19	CSA C22.2 No. 65	Wire Connectors.
.20	CSA C22.2 No. 14	Industrial Control Equipment.
.21	CSA C22.2 No. 177	Clock-Operated Switches
.22	CSA C22.2 No. 42	General Use Receptacles, Attachment Plugs, and Similar Wiring Devices
.23	CSA C22.2 No. 42.1	Cover Pates for Flush Mounted Wiring Devices
.24	C22.2 NO. 182.1	Plugs, Receptacles, and Cable Connectors of the Pin and Sleeve Type
.25	C22.2 NO. 182.2	Industrial Locking Type, Special Use Attachment Plugs, Receptacles and Connectors
.26	C22.2 NO. 182.3	Special Use Attachment Plugs, Receptacles and Connectors
.27	CSA C22.2 No. 4	Enclosed and Dead-Front Switches
.28	CSA C22.2 No. 111	General Use Snap Switches
.29	CSA C22.2 No. 55	Special Use Switches
.30	CSA C22.2 No. 106	HRC Miscellaneous Fuses
.31	CSA C22.2 No. 248	Low-Voltage Fuses
.32	Durham T-1036-2020	Supply and Delivery of Level II Electric Vehicle Charging Systems

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

1.5 Shop drawings

.1 Submit shop drawings for the equipment detailed within this specification section. Shop drawings shall be submitted in accordance with Section 26 05 00 – General Electrical Requirements and the requirements of Division 01.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 All material shall be specification grade, where applicable, new and carry C.S.A. approval or special approval in accordance with the requirements of the Electrical Safety Authority.

.2 Similar devices and items shall be from one manufacturer throughout the project.

2.3 Short circuit, Co-ordination and Arc Flash Hazard Study

.1 Engage the services of a specialized power systems consultant firm to perform a study of short circuit, protective device co-ordination and arc flash hazards in accordance with Section 26 05 73 – Arc Flash Risk Assessment. The study is to include the main 600V service entrance switchboard, automatic transfer switch and all downstream distribution panels rated 600/347 V, 400/230 V, 208/120 V and protective devices rated 30 Amp and larger.

.2 Each protective device shall be compared to the upstream device to confirm the downstream device trips before the upstream unit.

.3 Co-ordinate with local distribution company (Elexicon) to obtain/confirm system short circuit characteristics.

.4 Submit the study as a shop drawing and incorporate the recommendations.

2.4 Seismic support design

.1 Where member sizes are not provided on the Drawings, the Contractor shall provide the detailed design for support components and connections.

.2 Engage a Professional Engineer licensed in Ontario with demonstrated competence and familiarity in the design of mechanical and electrical support structures.

.3 The Contractor shall confirm and coordinate all requirements of the equipment loads with the designer, including the review of all equipment shop drawings.

.4 The design of supports and connections shall conform to the Ontario Building Code, incorporating requirements for an Importance Factor for Post-Disaster and Seismic requirements of OBC Part 4.

2.5 Wiring

.1 All conductors, unless specifically noted otherwise, shall be copper with 600 volt, x-link insulation. Temperature rating to be 90 °C or as required by OESC.

.2 All conductors shall be colour coded consistent with the Ontario Electrical Safety Code.

.3 Conductors up to and including #10 may be solid copper. Larger conductors shall be stranded.

.4 Branch circuit wiring shall be #12 AWG minimum. For circuit (15 Amp, 120 VAC) lengths exceeding 30 m (100 ft.) minimum size shall be #10 AWG and for circuit lengths exceeding 45 m (150 ft.) minimum size shall be #8AWG. Size wiring to maintain a maximum of 2 % voltage drop.

.5 Control wiring to be #16 AWG minimum. Size wiring to maintain a maximum of 2 % voltage drop.

.6 Light fixture dimming control wiring for 0-10 V proportional dimming to be #14 AWG minimum.

.7 Wiring in dry locations shall be: R90 or RW90 installed in EMT conduit (unless noted otherwise).

.8 Wiring in damp locations shall be: RW90 in conduit (conduit type as noted on drawings).

.9 Underground service entrance wiring shall be RWU90 in PVC duct or conduit.

.10 Armoured cable (AC90) shall be permitted in ceiling spaces for interconnection of lighting fixtures. Maximum length per location shall not exceed 3 m (10 ft.); utilize EMT conduit for longer lengths.

.11 All feeders shall be run in continuous length between power supply point and the load with no splices.

.12 Provide separate neutrals for electronic driver lighting circuits (do not share neutrals between lighting circuits).

.13 Sleeve and seal wiring through fire rated walls and floors, per Ontario Building Code requirements.

.14 Wiring in fire rated partitions shall be armoured cable.

2.6 Conduit

.1 EMT conduit shall be utilized for typical wiring. Conduit to be concealed wherever possible.

.2 Where conduit is surface mounted and subject to mechanical damage (garage area), use rigid galvanized steel threaded conduit to a minimum of 3 m (10 ft.) above finished floor level. Use electrical metallic tubing (EMT) above 3 m (10 ft.).

.3 Direct buried conduit shall be rigid PVC conduit with bond, as permitted by Code.

.4 Seal tight (flexible, PVC jacketed, metallic) conduit shall be used to connect motors and vibrating equipment; minimize length of runs where possible.

.5 Conduit installed in hazardous locations shall be threaded, rigid galvanized steel with approved seals and fittings as required. Alternatively, TECK 90HL cables may be utilized subject to review/acceptance by the Consultant.

.6 Concrete encased duct shall be PVC type DB2 with bond wire, as permitted by Code. The minimum cover to concrete surface shall be 53 mm.

.7 Minimum conduit size for lighting and power circuits shall be 21 mm (¾ in.) unless otherwise stated. All buried conduit or conduit embedded in concrete shall be minimum 27 mm diameter.

.8 Provide all pull boxes, junction boxes, terminal boxes, fittings, drains, plugs, cover plates, bushings, clips, rods, and accessories as required and appropriate.

.9 EMT conduit connectors to be c/w steel set screw.

.10 Where the potential for box submergence exists, the box is to have a submersible rating with all fittings designed and installed to prevent the entry of water.

.11 Supports for conduit, cable or equipment shall be corrosion resistant (galvanized steel or equivalent).

2.7 Wiring devices and coverplates

.1 General

.1 Colour of devices and coverplates (other than stainless) to be confirmed by Consultant.

.2 Acceptable Manufacturers: Hubbell, Bryant, Pass & Seymour, or approved alternate.

.3 All devices to be of the same manufacturer throughout.

.4 Special devices such as BAS integrated switches, receptacles, scene managers etc., shall be as per BAS supplier literature, premium grade, colour selection to be confirmed by Consultant through the shop drawing review process.

.2 Switches

.1 15A or 20A (as required by circuiting), 120V (or 347V as required), single pole switches. Provide 3-way or 4-way switches where noted on drawings.

.2 Manually operated general purpose ac switches with following features:

.1 Terminal holes approved for No. 10 AWG wire.

.2 Silver alloy contacts.

.3 Urea or melamine moulding for parts subject to carbon tracking.

.4 Suitable for back and side wiring.

.5 ‘Decora’ rocker style switches.

.6 Colour to be confirmed via shop drawing review. Provide brown switches for mechanical and/or service rooms.

.3 Fully rated for tungsten filament and fluorescent lamps, and up to 80 % of rated capacity of motor loads.

.4 BAS integrated switches as noted under 2.5-.1-.5.

.3 Receptacles

.1 Duplex receptacles, CSA type 5-15 R, 125 V, 15 A, U ground, with following features:

.1 Urea moulded housing.

.2 Suitable for No. 10 AWG for back and side wiring.

.3 Break-off links for use as split receptacles.

.4 Eight back wired entrances, four side wiring screws.

.5 Triple wipe contacts and riveted grounding contacts.

.2 Duplex receptacles, CSA type 5-20 R, 125 V, 20 A, U ground, with features detailed above for 15A device.

.3 Single receptacles CSA type 5-15 R, 125 V, 15 A, U ground with following features:

.1 Urea moulded housing.

.2 Suitable for No. 10 AWG for back and side wiring.

.3 Four back wired entrances, 2 side wiring screws.

.4 Other receptacles with ampacity and voltage as indicated.

.4 Duplex Ground Fault Interrupter Receptacle

.1 Rated 15 A or 20 A (as per drawings), 125 VAC, U-grounded type.

.2 Class A requirement, trip level 4-6 mA, parallel blade, with test and reset switches, CSA 5-15R/20R configuration.

Note: Except as specifically indicated, provision of either GFCI receptacle or GFCI circuit breaker will be acceptable to ensure ground fault protection of circuits as shown. Where GFCI circuit breaker is utilized, device coverplates shall be labelled to indicate they are GFCI protected.

.5 BAS controlled receptacles as noted under 2.5-.1-.5.

.4 Coverplates

.1 Cover plates shall be from one manufacturer throughout project.

.2 Stainless steel (302/302), smooth cover plates, for wiring devices mounted in flush-mounted outlet box.

.3 Sheet steel utility box cover for wiring devices installed in surface-mounted utility boxes.

.4 Sheet metal cover plates for wiring devices mounted in surface-mounted FS or FD type conduit boxes.

.5 Weatherproof locations: Provide cast aluminum cover (“while-in-use cover) complete with adapter plate and gaskets. Cover shall have “wet location” rating with or without a plug inserted into the receptacle.

.6 BAS controlled device cover plates as noted under 2.5-.1-.5

2.8 Outlet & conduit boxes

.1 General

.1 Gang boxes where wiring devices are grouped.

.2 Provide blank cover plates for boxes which are roughed in only. Cover plate style as detailed above.

.3 Provide 347 V outlet boxes for 347 V switching devices.

.4 Provide combination boxes with barriers where outlets for more than one system are grouped.

.2 Galvanized Steel Outlet Boxes

.1 One-piece electro-galvanized construction.

.2 Single and multi gang flush device boxes for flush installation, minimum size 78 x 53 x 41 mm (3 in. x 2 in. x 1½ in.) or as indicated. 102 mm (4 in.) square outlet boxes when more than one conduit enters one side with extension and plaster rings as required.

.3 Utility boxes for outlets connected to surface mounted EMT conduit, minimum size 103 x 53 x 53 mm (4 in. x 2 in. x 2 in.).

.4 103 mm (4 in.) square or octagonal outlet boxes for lighting fixture outlets.

.5 Extension and plaster rings for flush mounting devices in finished tile walls.

.3 Floor Boxes

.1 Adjustable, watertight, concrete tight, cast floor boxes with openings drilled and tapped for 21 and 27 mm conduit. Minimum size: 73 mm deep. Barriered interior compartments to accommodate communication/data and power/receptacle circuits.

.2 Where penetrating fire rated floor assembly, fire rated poke through (flush series) shall be utilized for power and data.

.4 Masonry Boxes

.1 Electro-galvanized steel masonry single and multi gang boxes for devices flush mounted in exposed block walls.

.5 Concrete Boxes

.1 Electro-galvanized sheet steel concrete type boxes for flush mount in concrete with matching extension and plaster rings as required.

.6 Conduit Boxes

.1 Where subject to mechanical damage (or as noted on drawings) provide cast FS or FD aluminum boxes with factory-threaded hubs and mounting feet for surface wiring of devices.

2.9 Ground & bonding

.1 Provide all grounding to the authorities' approval. Use approved connection methods (thermal weld or compression). Provide appropriate mechanical protection for all ground wire.

.2 Provide appropriately sized ground or bond wire in all conduit systems; including EMT, steel and PVC types.

.3 Provide #6 AWG insulated bond wire from main service ground to:

.1 Service entrance telecommunication backboard, and

.2 Telecommunication and IT/server rooms.

.4 Install three 19 x 3,000 mm long copper clad steel rod electrodes spaced at 3,000 mm intervals, interconnected with #2/0 bare Cu. buried conductor extended to grounding connection at main electrical service entrance per OESC.

.5 Provide grounding of emergency generator in accordance with OESC requirements. Generator system neutral shall not be bonded to generator frame. Provide ground conductor back to main electrical service ground.

.6 Engage the services of an independent contractor to undertake a ground resistance measurement on the grounding system prior to termination and backfill. A log of measurements shall be provided. Notify the Engineer if the resistance of any rod to earth is greater than 5 ohms.

.7 Supply and install supplementary 19 X 3,000 mm long copper clad steel rod electrodes as necessary to reduce overall system ground to earth resistance readings below 4 ohms.

2.10 Splitters

.1 Construction: sheet metal enclosure, welded corners and formed hinged cover suitable for locking in closed position.

.2 Terminations: main and branch lugs to match required size and number of incoming and outgoing conductors as indicated.

.3 Spare Terminals: minimum three spare terminals or lugs on each connection or lug block sized less than 400 A.

.4 Hammond, Hydel, Hoffman or approved alternate manufacturer.

2.11 Junction & pull boxes

.1 Construction: welded steel enclosure.

.2 Covers Flush Mounted: 25 mm (1 in.) minimum extension all around

.3 Covers Surface Mounted: screw-on flat steel covers.

2.12 BAS control boxes

.1 Construction: welded steel enclosure, lift-off cover, inner panel (mounting plate), ventilation plate, EEMAC12.

.2 Minimum dimensions: L 300 mm X W 200 mm x D 150 mm, Hammond or approved alternate.

.3 Control transformer: Hammond cat.# PH50PG or approved alternate, fused primary option, fused secondary, finger guard kit, minimum 50 VA, 120/24 Vac.

.4 DIN Rail provision.

2.13 Cabinets

.1 Construction: welded sheet steel, hinged door, handle, lock (2 keys) and catch.

.2 Metering Cabinet: Standard steel cabinet with double hinged doors. Supplied with pull catch and provision for padlocking. Grey enamel finish. Removable backplate for mounting of metering equipment by utility.

.3 Cabinet size 1220 x 1220 x 305 mm (48 in. x 48 in. x 12 in.) for CT's & PT's in cabinet or 765 x 765 x 255 (30 in. x 30 in. x 10 in.) for remote mounted CT's & PT's; refer to drawing for required size.

.4 Type E Empty: mounting and size as indicated.

.5 Type T Terminal: surface return flange, mounting as indicated, containing 19 mm (¾ in.) G1S fir plywood backboard.

2.14 Supporting devices

.1 Every conduit or cable shall be supported per OESC requirements. Only approved conduit supports will be accepted. Perforated pipe straps, tie wrap or wood support for conduits or outlet boxes etc., will not be accepted.

.2 Single conduit runs: Galvanized conduit straps, ring bolt type hangers or P.V.C. saddles.

.3 Horizontal multiple raceway runs: Conduit rack with minimum 25 % spare capacity. Trapeze style hanger on threaded rod.

.4 Vertical multiple raceway runs: Electrical strut fastened to structure.

.5 Strut Channels and Components

.1 General: Strut shall be 1-5/8 inches wide in varying heights and welded combinations as required to meet load capacities and designs indicated on the drawings.

.2 Materials and Finish: Hot-dip Galvanized Steel.

.1 Strut shall be manufactured from steel and hot-dip galvanized after fabrication.

.2 Fittings shall be manufactured from steel and hot-dip galvanized after fabrication.

.3 All hardware shall be stainless steel Type 304 or chromium zinc ASTM F1136 Gr. 3.

.3 Acceptable Manufacturers: Cooper B-Line, Thomas & Betts, or approved alternate.

2.15 Access doors

.1 Provide access doors in walls and ceilings to service electrical equipment and concealed devices requiring access. Positive latch system. Minimum 18-gauge steel.

.2 Group devices to minimize doors. Access doors in fire separations are to be ULC labelled. Doors shall match finish and be flush with surface.

.3 All sizes and locations of doors shall be approved in writing by the Owner and or Engineer before installation.

.4 Provide hinged doors for all access panels with a size of 450 x 450 (18 in. x 18 in.) or larger.

2.16 Cutting and patching

.1 Flashing and counter flashing.

.1 At all penetrations of the roof provide:

.1 Thaler or approved alternate aluminium mechanical/ electrical flashings with integral deck flange and EPDM seals, as recommended for specific purpose.

.2 Flashing and penetrations to meet warranty requirements of Section 07 41 13 – Metal Roof Panels and Section 07 62 00 – Prefinished Metal Flashing and Trim.

.3 All flashings will be supplied to accommodate an inverted roof system exposing no less than 300 mm (12 in.) above the top of the roofing system.

.1 Flexible Electrical Conduit: Thaler MEF-2A (2A1/2A2 as required) gooseneck shaped aluminum flashing with EPDN cap seal, or approved alternate. Provide the flashings in a NON-STANDARD height of 500 mm (20 in.).

.2 At all penetrations of the walls and floors provide Portals Plus Alumi-Flash, Pipe Portal, Pipe Boots and Quadraseals or Portals Plus Retrofit as manufactured by Portals Plus, Inc. or approved alternate. Seals shall be installed to the manufacturer's recommendations instructions and to the satisfaction of the Consultant.

.3 Cut and patch holes located incorrectly.

.4 Pneumatic hammers, drills, or explosive fasteners shall not be used without prior written approval from the Owner and/or Consultant.

.5 Openings on all electrical metal boxes shall be punched or cut.

2.17 Fire stopping

.1 Provide materials and systems capable of maintaining effective barrier against flame, smoke and gases.

.2 Comply with the requirements of CAN/ULC-S115, and do not exceed opening sized for which they have been tested.

.3 Systems to have an F or FT rating (as applicable) not less than the fire protection rating required for closures in a fire separation.

.4 The fire stopping materials are not to shrink, slump or sag and to be free of asbestos, halogens and volatile solvents.

.5 Fire stopping materials are to consist of a component sealant applied with a conventional caulking gun and trowel.

.6 Fire stop materials are to be capable of receiving finish materials in those areas which are exposed and scheduled to receive finishes.

.7 Acceptable Manufacturers:

.1 Fyresleeve Industries Inc.;

.2 General Electric Pensil Firestop Systems;

.3 International Protective Coatings Corp.;

.4 Rectorseal Corporation (Metacaulk);

.5 Proset Systems;

.6 Minnesota Mining and Manufacturing (3M);

.7 Tremco;

.8 Hilti; or

.9 Approved alternate.

.8 Submit shop drawings in accordance with Section 01 33 00 – Submittal Procedures, paragraph 1.4 for the following items:

.1 Fire stopping materials.

.2 Manufacturers literature and installation instructions.

.3 Manufacturers Letter of Certification that project meets or exceeds specified requirements.

2.18 Contactors

.1 Electrically held, controlled by pilot devices. Refer to drawings for confirmation of number of poles, amperage, voltage and pilot control devices.

.2 Coil voltage to match operating voltage.

.3 Complete with one (1) normally open and one (1) normally closed auxiliary contacts unless indicated otherwise.

.4 Mount in CSA Enclosure Type 1 unless otherwise indicated. Where noted as ‘Weatherproof’ or ‘WP’ mount in CSA Enclosure Type 3R.

.5 Include following options in cover:

.1 Red indicating lamp.

.2 Hand-Off-Auto selector switch.

.6 All contactors shall be one manufacturer. Acceptable Manufacturers: Eaton, Allen Bradley, Asco Electric, Schneider Electric, Siemens, or approved alternate.

2.19 Motor starters

.1 Manufacturers: Allen Bradley, Schneider Electric, Eaton, Siemens, or approved alternate.

.2 All starters shall be EEMAC rated.

.3 Manual Starters: Single phase, single and two pole - c/w pilot light and thermal overloads. EEMAC rated enclosure as required. Rated 115/230 volts. Sized as required for motor load to be controlled.

.4 AC Combination Magnetic Starters (FVNR unless noted otherwise) for Automatic Control of Single Phase and 3 Phase Loads:

.1 Provide each starter with an operating coil and adjustable, manually resettable, ambient compensated overload and phase loss relay, each motor phase winding to be sensed. Provide “Reset” pushbutton for the overload relays.

.2 Overload relays for each line voltage connection and heater elements to match nameplate FLA of motor controlled.

.3 Provide control transformer (size as required, minimum 50 VA) complete with primary fusing (HRC type). 120 VAC secondary winding to be fused and grounded.

.4 Provide one (1) normally open and one (1) normally closed, 120 V auxiliary interlock contacts.

.5 Provide ‘push to test’ LED type pilot lights, two (2) to indicate ‘Run’ (red) and ‘Stop’ (green).

.6 Fusible, three (3) pole load break disconnect style switch c/w HRC time delay fuses.

.7 Operating voltage of coil to match voltage of operating system.

.8 Provide H.O.A. switching as noted.

.5 Enclosures shall be general purpose EEMAC type 1 surface mounted unless specified or shown otherwise on the drawings. Use EEMAC type 3R in weatherproof applications.

2.20 Disconnect switches

.1 Disconnect switches shall be fusible or non-fusible as required. Refer to drawings for details regarding type of switch, voltage, amperage/HP, etc. Switches shall be supplied complete with the following features:

.1 CSA approved.

.2 Horsepower rated.

.3 Provision for padlocking in on or off switch position.

.4 Quick-make, quick-break action. 100 % load make / load break rated.

.5 ON-OFF switch position indication on switch enclosure cover.

.6 Mechanically interlocked door to prevent opening when handle in ON position.

.7 Suitable for service entrance use when noted.

.8 Fuseholders for type and size of fuse indicated. Provide fuses for each fused disconnect switch and three spare fuses for each size/type of fuse specified on project.

.9 CSA Enclosure type 1. Where indicated as ‘Weatherproof’ provide CSA Enclosure type 3R.

.2 All materials of similar type shall be of one manufacturer. Acceptable Manufacturers: Bryant, Eaton, Schneider Electric, Siemens, or approved alternate.

2.21 Fuses

.1 HRC fuses rated above 600 amperes shall be CSA certified HRC-L fuses, of the types(s) specified below.

.2 HRC fuses rated 600 amperes and smaller shall be CSA certified HRCI-J fuses of the type(s) specified below.

.3 Fuse interrupting rating shall be 200,000A RMS symmetrical, unless otherwise noted.

.4 Time Delay fuses shall carry 500 % of the rated current for a minimum of ten seconds and shall be labelled “Time Delay” by the manufacturer. (Exception: fuses rated 250 V, 15-30 A, an eight (8) second delay is permitted).

.5 Provide three (3) spare fuses of each type and size installed. Provide spare fuse storage cabinet.

.6 Submit fuse melting and clearing time-current characteristic and current-limiting performance data for each fuse type and size above 200 Amps.

.7 Select fuses to provide a fully co-ordinated system for both overload and short circuit fault conditions. Integrate fuse selection in power system studies.

.8 Unless otherwise noted on the drawings, Time Delay fuses for overcurrent protection of motor circuits are to be rated up to 150 % of motor full-load current.

.9 Manufacturers: Cooper/Bussman, Mersen/Ferraz Shawmut/Gould, Littelfuse, or approved alternate.

2.22 Electric Vehicle Chargers

.1 Provide Level II Electric Vehicle Charging System complete with the following:

.1 Shall have a digital screen, backlit for night-time use.

.2 Shall be certified to operate in temperatures ranging from -40°C to 50°C.

.3 User access provided with or without authentication as required by the Owner.

.4 User access provided free of charge or according to a usage fee as required by the Owner.

.5 RFID card and mobile app-based authentication and payment for iOS and Android.

.6 Ability to add the charger to a mapping system and/or EV charger network and must be able to provide real time information such as availability, in use or under maintenance.

.7 AC Power Input Rating: 208V/240VAC 60 Hz single phase @ 32A.

.8 Input Power Connections: One 40A branch circuit

.9 Maximum output current adjustable from 6A to 30A

.10 Supply Voltage: 208VAC or 240VAC nominal

.11 Integrated GFCI Circuit Breaker: 20 mA, auto reset (3 attempts at 15 minutes intervals)

.12 Charging Power: Maximum adjustable from 1.2kW to 7.2kW

.13 Charging Connector: SAE J1772

.14 Overhead Cable Management System

.15 LED status indicator (Green: Available White: In use)

.16 Aluminium Enclosure: NEMA 4X – Weather and vandalism proof, or Type 3R per UL 50E

.17 Cable: 18-25 foot ultra-flex cable, final length to be confirmed on site.

.18 Humidity: Up to 95% (non-condensing)

.19 Communication interface: ZigBee (IFEE 802.15.4 meshed network) or approved alternate

.20 Networking: 3G (Via communication gateway)

.21 Certifications: CSA certified for Canada and United States

.22 Safety Compliance: complies with UL 2594, UL 2231-1, UL 2231-2 and NEC Article 625

.23 Payment for charging in Canadian dollar

2.23 Transfer Switch

.1 Each transfer switch shall be positively interlocked both mechanically and electrically to prevent simultaneous closing of both sources during operation. Each transfer switch shall be capable of achieving a neutral position for systems maintenance purposes. A transfer switch position indicator shall be included on the face of the transfer mechanism to display the switch position.

.2 Transfer switches shall be capable of being operated manually under full rated load conditions. Manual operation shall provide true quick-make, quick-break operation to prevent possible flashovers from switching the contacts slowly.

.3 On transfer switches requiring a fourth pole for switching the neutral, the neutral shall be fully rated with equal withstand, closing and interrupting ratings to the power poles. The neutral pole contacts shall be of identical construction as, and operate simultaneously with, the main power contacts. Switched neutral poles, which are add-on or overlap or that are not capable of breaking full rated load current are not acceptable.

.4 Main contacts shall be designed, and type tested to withstand multiple fault currents and shall meet CSA 22.2 No. 178 and C22.2 No. 5.

.5 Each transfer switch shall come equipped with auxiliary contacts for switch position indication.

.6 Provide quick connect connections for portable generator and load bank connections where shown in the single line diagrams.

2.24 Communication Cabling and WAPs.

.1 Provide data communication cabling and wireless access points throughout the facility as shown on the drawings and per appended Durham Cable Specifications.

3 Execution

3.1 General

.1 Verify all wall and partition locations, door swings, light switch and other device locations.

.2 Install all equipment according to manufacturer's recommendations with adequate access and clearances.

.3 Provide acceptable painted metal shroud over cables and conduits around exterior or public areas to prevent climbing, as required.

.4 Install all equipment according to manufacturer's recommendations with adequate access and clearances.

.5 All wiring, receptacles, light switches to be added to finished existing walls shall be concealed if possible. If surface mounted equipment and wiremold raceway is proposed its location and type must be approved by the Owner before installation. At tender specify where surface equipment and conduits are proposed to be installed.

.6 Correct improperly installed work as directed by the Consultant or authorized inspector.

3.2 Short circuit, co-ordination & arc flash hazard study

.1 Ensure circuit protective devices such as overcurrent trips, relays and fuses are installed to required values and settings in conformance with approved power system study settings. Verify prior to energizing of circuits.

3.3 Wiring

.1 EMT conduit with RW90 is the preferred wiring method for lighting, power and control circuiting. Maximum armoured cable (BX) length of 3 m (10 ft.) may be acceptable in the ceiling space. Minimum lengths of armoured cable may be used in furred ceilings, hollow partitions and hollow walls. Use EMT only in masonry walls unless otherwise approved. No BX may lay on or clip to ceiling tiles or terminate in panels.

.2 Conductor length for parallel feeders to be identical.

.3 Wire or cable used for feeders shall be free of splices.

.4 Systems of different voltages shall be installed in separate raceways.

3.4 Conduits

.1 Provide and locate all sleeves required to pass wiring through building walls and floors and ceilings. Fill voids between conduits and sleeves with material and caulking sealant to suit application and fire rating.

.2 Do not place conduits in slabs in which slab thickness is less than four (4) times conduit diameter.

.3 Elevator requirements:

.1 Provide a 16 mm (½ in.), empty conduit through the hoist way wall for elevator cab on each floor, for lanterns and push buttons.

.2 Provide a 63 mm, (2 ½ in.), empty conduit from the elevator hoist way on the ground floor and extend to elevator control panel.

.3 Provide a 16 mm. (½ in.), empty conduit from the telephone backboard to the elevator control panel.

.4 Provide complete metal conduit system for door entry wiring.

.5 Provide empty conduit systems for phone, computer, cable TV outlets or as designated. Conduit as indicated or as a minimum: 27 mm (1 in.) EMT conduit from the outlet to 150 mm (6 in.) above the ceiling panel. In areas of open ceilings, conduit shall be continuous to cable tray or telecom room. Provide outlet boxes, cover plates, junction and pull boxes and fireproof backboards as required.

.6 Telephone, Computers and Cable TV shall be wired by the Owner authorized company. Provide the authorized installers for these systems with estimated installation dates at the start of construction and two (2) weeks prior to estimated pre-wiring dates. Co-ordinate with the end user authority and follow applicable installation guidelines.

.7 Co-ordinate with all trades to locate conduits in slabs, as required, before concrete pouring, record routing on prints.

.8 Co-ordinate and record exact routing of underground ducts and conduits. Establish elevation of ducts, schedule of work before installation.

.9 Supply and install expansion couplings where conduits cross construction joints.

.10 Install conduits on surface at lower trough of roof decking.

.11 All conduit and wiring within the building shall be run neatly and parallel to the building structure, above finished ceilings, within finished walls or below the floor. Conceal conduits as much as practical. It shall be supported from the building structure. Minimize horizontal runs along walls. Nails or tie wires are not acceptable. Do not caddie clip to ceiling hangers.

.12 Provide fish wire in all empty conduits.

3.5 Wiring devices

.1 Switches:

.1 Switches shall operate vertically, with handle in "UP" position when switch closed. Devices on three-way switches shall be off when all toggles are down.

.2 Install switches in gang type outlet box when more than one (1) switch is required in one (1) location.

.3 Mount toggle switches at height in accordance with Section 26 05 00 – General Electrical Requirements unless noted otherwise.

.2 Receptacles:

.1 Install receptacles in gang type outlet box when more than one (1) receptacle is required in one (1) location.

.2 Generally, mount receptacles with U-ground oriented down.

.3 Mount receptacles at height in accordance with Section 26 05 00 – General Electrical Requirements unless noted otherwise.

.4 Where split receptacle has one (1) portion switched, mount vertically and switch upper portion.

.5 In office areas and training rooms, 50 % of the receptacles shall be switched based on room occupancy in accordance with the requirements of the OBC and ASHRAE 90.1 standard. Utilize plug load control devices (supplied with BAS controls) for occupancy switching of noted receptacles. Ensure switched receptacles are a distinct colour (grey) from non-switched receptacles.

.3 Cover plates:

.1 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.

.2 Install suitable common cover plates where wiring devices are grouped.

.3 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.

3.6 Outlet & conduit boxes

.1 Gang power, voice and data outlets using gang boxes with barriers. Coordinate with voice and data wiring supplier and provide combination cover plates to suit.

.2 Mount all boxes, plumbed-true on vertical installations. Mount level on horizontal installations.

.3 In finished areas, all boxes to be installed flush mounted.

.4 All boxes to be supported independent of conduits or cables.

.5 Openings in all boxes shall be punched or cut, no burning of holes allowed.

.6 Fill all K.O. openings not used with proper filler plates.

.7 Door swings are to be determined from the Architectural drawings for switch locations.

.8 A variation of location of 3 m (10 ft.) shall be provided without cost to the Owner if requested before installation of equipment.

3.7 Grounding & bonding

.1 Install complete permanent, continuous grounding and bonding system including, electrodes, conductors, connectors, accessories. Where EMT is used, run bond wire in conduit.

.2 Install connectors in accordance with manufacturer's instructions.

.3 Protect exposed grounding conductors from mechanical injury.

.4 Make buried connections, and connections to conductive water main, electrodes, using copper welding by thermit process, permanent mechanical connectors or inspectable wrought copper compression connectors.

.5 Use mechanical connectors for grounding connections to equipment provided with lugs.

.6 Soldered joints not permitted.

.7 Install bonding wire for flexible conduit, connected at both ends to grounding bushing, solderless lug, clamp or cup washer and screw. Neatly cleat bonding wire to exterior of flexible conduit.

.8 Install flexible ground straps for bus duct enclosure joints, where such bonding is not inherently provided with equipment.

.9 Install separate bond conductor to outdoor lighting standards.

.10 Connect building structural steel and metal siding to ground by welding copper to steel.

.11 Make bonding connections in radial configuration only, with connections terminating at single grounding point. Avoid loop connections.

.12 Bond single conductor, metallic armoured cables to cabinet at supply end, and provide non-metallic entry plate at load end.

.13 Equipment Grounding

.1 Install grounding connection to service entrance equipment. Provide bonding connections to typical equipment included in, but not necessarily limited to following list:

.1 Transformers, duct systems, frames of motors, starters, control panels, building steel work, generators, elevators, distribution panels, and outdoor lighting.

3.8 Junction & pull boxes

.1 Install junction and pull junction boxes so they are supported independent of raceways.

.2 Install pull boxes after every 30 m (100 ft.) of continuous raceway.

.3 Locate pull boxes above accessible ceiling spaces in inconspicuous locations wherever possible.

.4 Colour code pull boxes to indicate system involved.

3.9 Cabinets

.1 Mount all surface mounted equipment enclosures on an approved fire rated backing, or Unistrut channels.

.2 All recessed enclosures shall have trim for recessed mounting.

.3 Enclosures mounted in finished areas shall be finished to match.

.4 Terminate wiring in screw type terminal blocks or strips.

3.10 Supporting devices

.1 Install supporting devices to maintain headroom and clearances as described for conduits and conductors.

.2 Maintain a neat appearance and follow building lines where possible.

3.11 Access doors

.1 Provide access panels where required for electrical equipment concealed in walls, partitions, or floors. Location and type of access panels shall be to the Consultant's approval.

.2 Paint access panels to match surrounding decor or as directed by the Consultant on site.

.3 Keep access doors to a minimum by locating equipment in easily accessible locations.

3.12 Fire stopping

.1 Confirm location and extent of fire separations from architectural drawings.

.2 Inspect surface to be fire stopped. Report unsatisfactory conditions to Consultant in writing prior to commencement of work. Initiation of work to be deemed as acceptance of conditions and surfaces.

.3 Store all materials in accordance with manufacturers recommendations as to acceptable ambient temperatures. Damaged or deteriorated materials are not to be used and are to be removed from the site.

.4 Install fire stopping and smoke seal material and components in accordance with ULC certification and manufacturer’s instructions in all conduit, cable, duct etc. penetrations in new or existing fire separation to provide temperature, flame and smoke rated seals not less than the fire resistance rating of the assembly, or separation.

.5 Seal all holes made by through-penetrations and un-penetrated openings to ensure continuity and integrating of fire separation, including where existing component or device has been removed.

.6 Notify Consultant and/or Authority having jurisdiction for inspection prior to concealing or enclosing fire stopping materials and service penetrations.

.7 Remove excess material and debris and clean adjacent surfaces immediately after application. Leave in a tidy condition.

3.13 Contactors

.1 Install contactors and connect auxiliary control devices.

.2 Locate contactors in a convenient location for accessibility and service. Wherever possible, locate in service spaces such as electrical rooms, mechanical rooms, janitors' closets, etc. Provide a self-supporting mounting surface where required.

.3 Label each contactor to indicate the device it controls.

3.14 Motor starters

.1 Install starters and control devices in accordance with manufacturer's instructions.

.2 Install and wire starters and controls as indicated.

.3 Ensure correct fuses are installed in starters.

.4 Confirm motor nameplate and adjust overload devices to suit.

.5 Check that sequence controls, interlocking with other separate related starters, equipment, control devices, operate as indicated.

3.15 Disconnect switches

.1 Label each disconnect switch to indicate the device it controls.

.2 Provide a separate self-supporting structure to support the disconnect device where the equipment or adjacent walls are not capable of supporting the device.

.3 Install fuses in fused disconnect switches as detailed on drawings.

3.16 Fuses

.1 Ship fuses in original containers

.2 Do not ship equipment with fuses installed.

.3 Store spare fuses in original containers in fuse storage cabinet. Install fuse storage cabinet in electrical room.

.4 Prior to energization of any circuit, verify that the correct fuse is installed:

.1 for the calculated or assumed circuit capacity, and

.2 for the proper equipment and conductor protection requirements.

3.17 Electrical Vehicle Chargers

.1 Manufacturer's representative shall on-site during installation of EV chargers.

.2 Assemble and hook up EV charging station on site, provide power connection to electrical infrastructure.

.3 EV chargers to be installed according to AODA requirements.

.4 Manufacturer to provide initial activation and set up of the EV charging station on site.

.5 The Contractor is to provide Management services for a duration of 5 years which includes at minimum:

.1 24/7 operation of a transactional website enabling users to register, and transfer funds required to pay for the charging service

.2 Subscription to a 3G Telecommunication service for each Gateway required

.3 Management of each account associated to each Access Card in service.

.4 24/7 operation of an "Owner's Web Portal" providing the Owner the capability to issue different types of reports associated to the Charging Service provided and the Revenues collected by the Charging Stations

.5 Real time monitoring from its Network Operation Center during normal business hours of the operating condition of each Charging Station.

.6 Online data portal with access to real time and historical consumptions and usage trends for the term of the management agreement.

.7 Capability of the Owner to remotely configure the Charging Stations either by themselves using the Owner's Web Portal, or through the Contractor's Customer service agent.

3.18 Communication Cabling and WAPs

.1 Install communication cabling and Wireless Access points as per Durham Region Cable Specifications.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

1.2 Related requirements

.1 Section 03 30 00 – Cast-in-Place Concrete

.2 Section 26 05 00 – General Electrical Requirements

1.3 References

.1 Ontario Electrical Safety Code

.2 Electrical Safety Authority

.3 Elexicon Energy Standards

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Scope

.1 Provide all excavation, fill, and backfill, including repair/restoration of existing surfaces (i.e. pavement, sod, concrete, etc.), as required for the installation of underground services and underground feeders, as outlined on the drawings.

.2 Provide underground ducts, duct banks, pulling pits and cables as detailed on drawings.

.3 Provide interconnection of electrical service with existing outdoor switchboard.

.4 Provide concrete bases for lighting poles.

1.6 Shop drawings

.1 Submit shop drawings in accordance with Section 26 05 00 – General Electrical Requirements and the requirements of Division 01.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 All material shall be specification grade, new and carry CSA approval.

.2 All ducts, cables and miscellaneous materials required shall be the responsibility of this Division. Coordinate installation with General Division.

.3 Concrete used (for encasement of ducts) shall have a minimum strength of 2,500 psi (15 MPA) and the aggregate used in the concrete should be small enough (9.5 mm) to allow to flow freely around ducts.

3 Execution

3.1 General

.1 Coordinate work with local utilities; obtain underground service locates prior to start of work.

.2 Seal and drain all underground ducts in accordance with Section 22 of the Ontario Electrical Safety Code.

.3 Use bell ends at duct terminations.

.4 Unless noted otherwise on drawings:

.1 All underground ducts shall be surrounded in 150 mm (6 in.) of sand in non-vehicular areas.

.2 All underground ducts shall be encased 75 mm (3 in.) of concrete where ducts pass under vehicular areas.

3.2 Trenching

.1 The width and depth of the trench shall be such as to allow room for a 75 mm (3 in.) sand or concrete envelope (as required) around the duct bank and allow sufficient cover.

.2 The bottom of the trench must be graded evenly and the soil in the bottom of the trench must be undisturbed. Over break must be filled with compacted granular material or concrete. Ensure that no water traps are formed in individual ducts.

.3 Ensure that the ducts are properly plugged prior to backfilling or concrete encasement.

3.3 Direct burial of cables

.1 After sand bed is in place, lay cables maintaining 75 mm (3 in.) clearance from each side of trench to nearest cable. Do not pull cable into trench.

.2 Provide offsets for thermal action and minor earth movements. Offset cables 150 mm (6 in.) for each 60 m (200 ft.) run, maintaining minimum cable separation and bending radius requirements.

.3 Underground cable splices are not acceptable.

.4 Cable separation:

.1 Maintain 75 mm (3 in.) minimum separation between cables of different circuits.

.2 Maintain 305 mm (12 in.) horizontal separation between low and high voltage cables.

.3 When low voltage cables cross high voltage cables maintain 305 mm (12 in.) vertical separation with low voltage cables in upper position.

.4 Maintain 305 mm (12 in.) minimum lateral and vertical separation for fire alarm and control cables when crossing other cables, with fire alarm and control cables in upper position.

.5 Install treated planks on lower cables 610 mm (2 ft.) in each direction at crossings.

3.4 Concrete encased duct bank

.1 Erect a self-supporting structure with the ducts in position before pouring the concrete. Use spacers to establish required vertical and horizontal separation in the duct assembly. Provide reinforcing bars as detailed on drawings.

.2 Concrete shall not be poured when the temperature is below freezing without special precautions. If concrete is poured in freezing weather, heated aggregates and non-corrosive additives shall be used. After pouring, the concrete shall be covered.

.3 To prevent any displacement of the duct structure during pouring, the concrete shall be deflected down alongside the structure to the bottom and up through the assembly.

.4 Concrete shall be poured into the trench until the top layer of ducts is covered to a minimum depth of 75 mm. Chutes should be used when pouring so that the aggregate does not separate. Concrete must not be allowed to freefall more than 3 ft. 0 in.

.5 The end of the duct structure shall be properly blocked and supported so that a smooth face is attained and no concrete enters the mouth of the ducts.

.6 Warning tape shall be placed approximately midway between top of ductbank structure and finished grade to avoid future damage or injury.

3.5 Cleaning ducts

.1 Clean completed duct runs by pulling an approved cleaning device through the ducts by means of a winch line. Tail the cleaning device with a second winch line to permit withdrawal in case of blockage. Clean the ducts in the presence of Consultant or authorized representative.

.2 Provide a polypropylene rope 6 mm in diameter in each duct for future pulling of cables.

.3 At ends of the ductbank plug the ducts and mark the duct bank location.

3.6 Cable installation in ducts

.1 Install cables as indicated in ducts.

.2 Do not pull spliced cables inside ducts.

.3 Install multiple cables in duct simultaneously.

.4 Use CSA approved lubricants of type compatible with cable jacket to reduce pulling tension.

.5 To facilitate matching of colour coded multi-conductor control cables reel off in same direction during installation.

.6 Before pulling cable into ducts and until cables are properly terminated, seal ends of cables with moisture seal tape.

.7 After installation of cables, seal duct ends with duct sealing compound.

3.7 Markers

.1 Install marking tape (4-mil polyethylene) buried approximately halfway between grade level and the ducts/cables. Marking tape shall be installed over the complete width and length of duct/cable run.

3.8 Field quality control

.1 Perform tests in accordance with Section 26 05 00 – General Electrical Requirements.

.2 Perform tests using qualified personnel. Provide necessary instruments and equipment.

.3 Check phase rotation of service entrance cables and identify each phase conductor of each feeder.

.4 Check each feeder for continuity, short circuits and grounds.

.5 After installing cable but before terminating, perform insulation resistance test with 1,000 V megger on each phase conductor.

.6 Resistance to ground of circuits shall be not less than 50 meg-ohms. Remove and replace entire length of cable if cable fails to meet test criteria.

End of section

1 General

1.1 Introduction

.1 The Region of Durham has identified the need to perform Arc Flash Risk Assessment in its new and existing facilities in order to exercise its due diligence in protecting employees, contactors and other personnel from electrical hazards in the workplace. This is in conjunction with other aspects of its overall Electrical Safety Program.

.2 The Region is inviting qualified Engineering Contractors to perform an Arc Flash Risk Assessment.

1.2 Scope of work

.1 This specification defines the minimum technical requirements governing the performance of a complete Arc Flash Risk Assessment for existing buildings or new construction projects and renovations for buildings owned and/or managed by the Region of Durham.

.2 Revise and/or construct a comprehensive and up-to-date electrical distribution system Single Line Diagram (SLD) using AutoCAD for the entire facility. The SLD shall include all major electrical equipment identified in Section 2.01.

.3 A Short Circuit and Protective Device Coordination study for the electrical distribution system shall be performed before performing the Arc Flash Risk Assessment. The intent of the Short Circuit Study is to identify underrated equipment and to increase facility reliability, equipment protection and personnel safety. The intent of the Protective Device Coordination Study is to increase facility reliability by limiting the effects of a fault to the smallest portion of the distribution system.

.4 Perform an Arc Flash Risk Assessment for the entire facility's electrical distribution system based on the up-to-date Single Line Diagram. The intent of the Arc Flash Risk Assessment is to determine the level of hazard that exists at each major piece of electrical equipment shown on the Single Line Diagram and/or information collected on site. This includes switchgear, switchboards, panelboards, motor control centers, control panels, disconnects, cables and transformers.

.5 The Arc Flash Risk Assessment shall consider all expected operating scenarios during normal conditions, alternate operations, emergency power conditions, and any other operations, which could result in maximum arc flash hazard. The Arc Flash warning labels shall list the maximum incidental energy calculated and the scenario from which it is derived shall be documented in the final report. The following is a sample list of common operating scenarios:

.1 Normal or Reduced Utility Power

.2 Emergency Generator Power

.3 Bus Tie Breakers open

.4 Bus Tie Breakers closed

.5 UPS Power

.6 Parallel Generation

.7 Contribution of large motors

.6 Any documented information pertaining to existing equipment shall be provided by the Region of Durham. Any outstanding data shall be collected on site by the Engineering Contractor performing the study.

.7 It is the Engineering Contractor's responsibility to obtain qualified and competent personnel to safely perform on-site data collection without hindering the Region's normal operations.

.8 A detailed Arc Flash Risk Assessment report shall be provided to the owner at the completion of the study. The report shall contain and list all electrical equipment modeled in the study and the results of the Short Circuit study, Protective Device Coordination, and Arc Flash study.

.9 Recommendations shall be included in the report to mitigate any hazard above an incident energy of 12 cal/cm^2 at the specified working distance. Solutions shall be cost-effective, and mindful of the operating and maintenance requirements.

.10 For new construction projects, these recommendations shall be documented in sufficient time for changes to be made in the power system design to avoid creating a location of high hazard.

.11 The study will include the creation of Arc Flash Hazard and Shock Warning Labels listing all items as shown on the sample label in Section

2.08. These labels serve as a guide to assist technicians and others in the selection of proper Personal Protective Equipment when working on and around exposed and energized conductors and equipment.

.12 The Labels will be produced and installed in the locations by the Engineering Contractor as required by applicable regulatory standards and specifications identified herein.

.13 It is the intention of the Region to have the scope of work completed within 30 business days from the first day of data collection.

.14 Deliverables:

.1 Interim report for review by the Region on completion of the data collection phase (Refer to Section 2.06)

.2 Draft report for review by the Region before printing the arc flash hazard warning labels. (Refer to Section 2.06)

.3 Short Circuit Study and Protective Device Coordination Study

.4 Arc Flash Risk Assessment

.5 Arc Flash Labels

.6 Completion report that the scope of work has been completed per this Specification (Refer to Section 3.01)

1.3 Applicable standards

.1 The following standards are applicable to the collection of data, modeling, calculation, and evaluation methodology required for the Arc Flash Risk Assessment. The Engineering Contractor is expected to know and utilize the best practices and methods outlined in these standards.

.1 Ontario Electrical Safety Code

.2 Occupational Health and Safety Act and Regulations for Industrial Establishments

.3 Occupational Health and Safety Act and Regulations for Construction Projects

.4 CSA Z462 - Workplace Electrical Safety

.5 CAN/CSA-Z460 - Control of Hazardous Energy - Lockout and Other Methods

.6 IEEE 1584 - IEEE Guide for Performing Arc Flash Hazard Calculations

.7 IEEE 242 (Buff Book) - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

.8 IEEE 1015 (Blue Book) - IEEE Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems

.9 IEEE 241 (Gray Book) - IEEE Recommended Practice for Electric Power Systems in Commercial Buildings

.10 IEEE 399 (Brown Book) - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis.

.2 Where references to Codes and Standards are made, the latest version shall be applicable for the purposes of this specification.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Definitions

.1 The following definitions will be applicable to this specification:

.1 Arc Flash Calculation – Determination of the available incident energy which could be released under electrical fault conditions at various points in the power distribution system.

.2 Arc Flash Software – This is a commercially available software package which specializes in power distribution analysis and has the ability to perform calculations and provide the necessary information required to generate reports and print labels as described further in this specification.

.3 Certificate of Authorization – This is a formal authorization by the PEO for a firm to offer engineering, design, and technical services to the general public.

.4 Electrical Distribution System – This term references the facility's electrical distribution system in its entirety without exclusions. The scope is to include all equipment/systems greater or equal to 208/120 V.

.5 Engineering Contractor – A firm who holds a Certificate of Authorization from the PEO and is technically qualified to perform the work described in this specification.

.6 Existing Facility – A Regional facility which is existing or where a minor renovation is to be performed.

.7 Independent Engineer – Licensed Professional Electrical Engineer engaged by the Region to review the results and recommendations of the Arc Flash Risk Assessment.

.8 Warning Label – This is a self-adhesive label which contains the necessary information (as described by CSA Z462 and further in this specification to inform a worker of Arc Flash and Shock Hazards.

.9 Local Distribution Company (LDC) or Utility – Authority having jurisdiction for the supply of electricity to the facility.

.10 OESC – Ontario Electrical Safety Code

.11 PEO – Professional Engineers Ontario

.12 PPE – Personal Protective Equipment for arc flash and shock protection as identified by the Region guidelines.

.13 Protective Device Coordination – An analysis and graphical representation of the performance characteristics of protective devices in the power distribution system. It primarily assesses the ability of a power distribution system to clear and isolate an electrical fault so as not to adversely affect other parts of the system.

.14 Qualified Engineer – A professional electrical engineer licensed in the Province of Ontario who will perform, supervise, and be responsible for and technically qualifies to perform the work described in this specification.

.15 Region – Regional Municipality of Durham

.16 Short Circuit Study – A calculation of the available short circuit current levels at various points in the power distribution system to determine if the equipment can clear or withstand and electrical fault without damage to the system.

.17 Single Line Diagram (SLD) – Sometimes referred to as a one line drawing or power schematic, this diagram represents the relationships and connections of the electrical equipment and protective devices in the power distribution system.

.18 Time Current Curves (TCC) - A time current curve plots the interrupting time of an overcurrent device based on a given current level. These curves are typically provided by the manufacturers of electrical overcurrent interrupting devices, such as fuses and circuit breakers.

1.6 Qualifications

.1 The pre-qualified Engineering Contractor shall acknowledge and confirm the following qualifications.

.1 The Arc Flash Risk Assessment must be undertaken by an Engineering Contractor who is in possession of a valid Certificate of Authorization from the PEO allowing it to offer engineering, design, and technical services to the general public.

.2 The Engineering Contractor must be presently involved with medium and low voltage power system analysis.

.3 The study shall be performed by and/or supervised by a Qualified Engineer of the Engineering Contractor. The Qualified Engineer shall be a Registered Professional Electrical Engineer licensed in Ontario who has relevant work experience and academic background in the power systems industry. The Qualified Engineer must be a full-time employee of the Engineering Contractor and have at least five (5) years of relevant experience in power system analysis.

.4 The arc flash hazard study shall be performed using SKM Power Tools, ETAP, or an equivalent commercially available Arc Flash Software package. The Region shall evaluate the suitability of any

proposed software package and accept or reject its use on the project at their sole discretion. The use of single point software or CSA Z462 Task Tables to determine Arc Flash Hazard Classification is not acceptable.

.5 The Engineering Contractor must have the most recent (within six months) legal version of the Arc Flash software that is up-to-date with the most current applicable standards including CSA Z462-2015. The maintenance agreement of the software must be in force and valid. The Engineering Contractor must show evidence that the Qualified Engineer has formal vendor training in use of the Arc Flash Software.

.2 Data collection may be subcontracted to Licensed Electrical Consultants/Contractors.

1.7 Submittals for new construction (to be supplied with shop drawings)

.1 The proposal for this study must include the following items:

.1 Estimate of number equipment locations to be modeled.

.2 Estimate of number of labels to be supplied.

.3 Subcontractor performing data collection

.4 Subcontractor performing label installation

.5 Statement of Software Manufacturer and Version

.6 Estimate of number of working days for data collection, and completion of preliminary and final reports.

.7 Operating scenarios to be included in the Analysis.

.8 Contractor PEO Certificate of Authorization registration number

.9 Contractor website URL

.10 Qualified Engineers License number

.11 Resumé of Qualified Engineer

.12 Copy of formal software training certificate

.13 Three references of projects completed within last three years

.14 Sample Arc Flash Hazard Analysis report

1.8 Site access

.1 All site access will be coordinated through a designated Region of Durham representative and confirmed in advance. The Contractor shall take reasonable care to minimize disruption to the building occupants and operation. All inquiries, direct communication for all approvals, concerns and general management issues of the projects will also be directed to the Region's Representative. Contact information will be given to the successful contractor upon award of the Contract.

.2 The Contractor must allow for at least 10 % site visit cancellation per building access due to change of circumstances.

.3 Working hours are from 8:30 a.m. to 4:30 p.m. Monday to Friday.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Data collection – new facilities

.1 The Engineering Contractor shall obtain all data pertinent to the electrical system which will be necessary to perform the Short Circuit Study, Protective Device Coordination Study and the Arc Flash Risk Assessment. This includes the collection of all Single Line Diagrams, schematics, shop drawings, equipment manuals, etc. This also includes equipment ratings, sizes, settings and types. This includes but is not limited to:

.1 Utility Data

.2 Switchgear/Switchboards

.3 Panelboards

.4 Transformers

.5 Generators

.6 Circuit Breakers

.7 Fuses

.8 Protective Relays

.9 Motor Control Centers

.10 Control Panels

.11 Motor Starters

.12 Conductors and Cables

.13 Automatic Transfer Switches (ATSs)

.14 Bus Ducts

.15 UPS

.16 Safety Disconnect Switches

.17 Motors

.18 Variable Frequency Drives (VFDs)

.19 Inverters/Rectifiers

.20 Renewable Generation Equipment

.21 Other Equipment

.2 Data collection sheets shall be used and kept for data back-up and subsequent confirmation of data. A sample data collection sheet is attached to this specification. This data shall be documented in the report and in a CSV format electronic file.

.3 The Engineering Contractor shall investigate available manufacturer documentation to obtain the necessary data. Where data is unavailable, the Engineering Contractor will identify the equipment in the report and describe what assumptions were made in supplying alternate data.

.4 The Engineering Contractor shall obtain Utility short circuit capacity and system impedance data for expected operation of the Utility distribution system. This can change depending on grid configuration. Assuming “rule of thumb” values or maximum short circuit values is not acceptable for the purposes of the Arc Flash Risk Assessment. All Utility information shall be documented formally and signed by the LDC Distribution Engineer.

.5 Personnel collecting data (in case field data collection may become necessary) shall be trained in Electrical Safety and Arc Flash Awareness and dressed appropriately in PPE adequate for the hazard. A preliminary study of the main incoming service and other potentially high hazard locations shall be performed to determine the incident energy at these

points in the power distribution system to ensure data collection personnel is adequately informed and protected.

.6 Exposure to voltages over 300 volts shall require the Engineering Contractor to provide a competent person to assist in the data collection per Regulation 851, Section 42.1. or per Regulation 213, Section 189.

.7 If it is necessary to shut down equipment to safely determine collected data, the Engineering Contractor shall advise the Region and a mutually suitable time will be arranged when the equipment can be shut down. The Engineering Contractor or its subcontractor shall not shut down equipment or otherwise disturb the operation of the facility without pre-approval from the Region.

2.3 Single line diagram

.1 The Engineering Contractor shall verify and update existing Single Line Diagrams or create new where one is not available, using information from the data collection phase for existing facilities. The Engineering Contractor shall prepare a Model in the Arc Flash Software based on the accurate and up-to-date Single Line Diagram.

.2 All Single Line Diagrams shall represent the entire facility's electrical distribution system until a 100 A bus is reached at the 208 volt level.

.3 The Single Line Model shall be exported to AutoCAD to prepare a revised Single Line Diagram to be used for subsequent work and documenting the system model and results in the report.

.4 Common electrical distribution components and its respective minimum required information are indicated in Appendix 1 and shall be presented in the SLD drawing. Two SLD layers shall be provided. Arc Flash report information shall be indicated in one AutoCAD layer (E-SLD-ARC). Another layer (E-SLD) shall be created containing a different set of information, as indicated in Appendix 1. This information shall be arranged so that when one layer is turned on it will not interfere with information on the other layers.

.5 Calculated arc flash incident energy levels should be color coded in the following manner:

.1 <1.2 cal/cm^2 = Green

.2 ≥1.2 cal/cm^2 to <12 cal/cm^2 = Blue

.3 ≥12 cal/cm^2 to <40 cal/cm^2 = Orange

.4 ≥40 cal/cm^2 = Red

.6 AutoCad drawings shall be provided in 11 in. x 17 in. format, and in 24 in. x 36 in. (ARCH D) format. Text on both print formats shall be Arial size 7 font or larger. Revision, dates and other information in Title block must have a minimum Arial size 4 font.

.7 Drawing Title Block shall include the Contractor's company name, name of the drawing, drawing number, address of the building, ROW assigned building code, revisions and dates, draft person's and reviewer's name. An AutoCAD drawing template will be provided to the Engineering Contractor.

.8 The single line diagram shall have a top down layout, starting with the utility station/substation at the top and working downwards, ending at major equipment and electrical panels.

.9 Standardized SLD symbols shall be used and will be provided to the Engineer Contractor.

2.4 Short circuit study

.1 A Short Circuit Study shall be performed on the equipment as per the up-to-date Single Line Diagram.

.2 The short circuit current available at each bus in the system shall be calculated per the applicable standards. The results shall be compared with the equipment short circuit ratings as per IEEE Standard 1015 and IEEE Standard 242 to ensure that all equipment is compliant with rule 14-012 of the Ontario Electrical Safety Code. Verify that the equipment is properly rated for the available bolted three phase short circuit current.

.3 The short circuit study shall consider all potential fault current sources. Motors less than 50 HP will not be considered a significant source.

.4 The study will be continued downward into the system until a 100 A bus is reached at the 208 volt level. Only the largest or slowest protective device on each bus needs to be represented in the study.

.5 Short circuit calculations shall be based on transient and sub-transient impedances of fault sources. X/R ratio analysis shall be used where asymmetric fault current may be an issue.

.6 Where actual equipment data is not available, the IEEE Gray Book shall be used as an alternate source. This shall be documented in the report.

.7 Recommendations from the Short Circuit Study shall be provided.

2.5 Protective device coordination study

.1 A Protective Device Coordination Study shall be performed for the equipment as per the up-to-date Single Line Diagram.

.2 The study shall include the main service and secondary switchgear for the facility. Utility protective devices and short circuit levels shall be included in the study. The results of this analysis will be documented in a log-log TCC representation including all cables, transformation, cables, circuit breakers and fuses. Where grounding protection is applicable, it shall also be included. This information shall be included in the final report.

.3 For each TCC graph, a complete title and single line diagram with legend identifying the specific portion of the system covered.

.4 Identify the device associated with each curve by type, function, and if applicable, tap, time delay, and instantaneous settings recommended.

.5 The study will be continued downward into the system until a 100 A bus is reached at the 208 volt level. Only the largest or slowest protective device on each bus needs to be represented in the study.

.6 All protective devices settings and ratings shall be documented in the report.

.7 Any miss-coordination uncovered shall be depicted in a log-log TCC plot showing the details of the miss-coordination and description of the situation along with a recommended solution and anticipated improvement.

.8 Recommended settings for the protective devices shall be provided to improve the situation.

2.6 Arc flash risk assessment

.1 The Arc Flash Hazard Analysis shall be performed once the Short Circuit Study and the Protective Device Coordination Study have been completed.

.2 The modeling and analysis shall be performed using SKM PowerTools, ETAP, or an equivalent commercially available Arc Flash Software package. Pertinent data, rationale employed, and assumptions in developing the calculations shall be incorporated in the final report.

.3 The analysis shall be in accordance with latest applicable IEEE 1584, CSA-Z462 Standards. Arc Flash Calculations shall use the IEEE 1584 method for equipment rated 50 V to 15 kV. The Lee Method shall be used for equipment rated above 15 kV.

.4 The Engineering Contractor shall utilize the best practices and guidelines identified in IEEE 1584 to provide accurate and usable results.

.5 Direct current, single phase systems, and certain higher voltages do not have valid results using the IEEE1584 methods. Alternative methods or assumptions must be made by the Engineering Contractor to deal with these situations. There are alternative methods described in CSA Z462 and other papers which may be utilized. The Engineering Contractor shall document where alternative methods have been used and the rationale justifying these methods.

.6 Design and print Arc Flash Warning Labels as shown in Figure 1. Include information as described.

.7 The Engineering Contractor shall analyze and make practical and cost-effective recommendations to reduce the hazard potential for any location above an incident energy of 12 cal/cm^2.

.8 An Arc Flash Risk Assessment evaluation table shall list the following items:

.1 Bus Name

.2 Location (Room number)

.3 Scenario

.4 Upstream Protective Device Name, Type, and Settings

.5 Bus Line to Line Voltage

.6 Bus Bolted Fault Current

.7 Bus Arcing Fault Current

.8 Protective Device Bolted Fault Current

.9 Protective Device Arcing Fault Current

.10 Protective Device Trip / Delay Time

.11 Breaker Opening Time

.12 Solidly Grounded Column

.13 Equipment Type

.14 Gap

.15 Arc Flash Boundary

.16 Working Distance

.17 Incident Energy

2.7 Progress submittals

.1 The Engineering Contractor shall submit an interim report for review by the Region on completion of the data collection phase. This will identify any data that was difficult to acquire or not available. This is so that measures can be implemented to capture the data or agree upon reasonable data substitution. It will also identify any system deficiencies or OESC violations uncovered during the data collection phase.

.2 Recommendations to reduce incident energy level beyond 12 cal/cm2 or recommendations to adjust/replace parts to better improve system protection coordination shall be reviewed by the Region when the analysis phase is completed.

.3 The Engineering Contractor shall submit a draft report for review by the Region before printing the arc flash hazard warning labels. The report will have a table showing the equipment locations and the incident energy at the specified working distance. The draft report shall be accompanied by a PDF file of copies of the proposed labels, and in editable electronic format.

.4 The Engineering Contractor shall submit the final Arc Flash Risk Assessment report and Arc Flash and Shock Hazard Warning Labels on completion of the analysis, based on the recommendations accepted by the Region.

2.8 Arc flash risk assessment report

.1 A written report shall be provided for each site. Multiple buildings located on the same address may be combined into one report as long as the findings are clearly defined per building. Each report will be named in the following manner: “M. <Building Name> (<Building Code>) - <Address with City> ARC <Date of report>”.

.2 The Arc Flash Risk Assessment Report shall contain at a minimum the following information and analysis:

- .1 Table of Contents
- .2 Executive Summary and Recommendations
- .3 Introduction / Scope / Purpose / Assumptions / Methodology
- .4 Scenario Explanations
- .5 Short Circuit Study description, results, and discussion
- .6 Protective Device Coordination Study description, , results, and discussion
- .7 Arc Flash Evaluation description, results, and discussion
- .8 Single Line Diagram
- .9 Equipment and Cable Data Summary Table
- .10 Utility Data
- .11 Protective Device Ratings and Settings
- .12 Colored Time Current Curves
- .13 Arc Flash Evaluation Report (All Scenarios)
- .14 Equipment Evaluation Table (Short Circuit study)
- .15 Existing and Recommended Protective Device Settings
- .16 Design improvements/upgrades to mitigate Arc Flash Hazards
- .17 Design improvements/upgrades to mitigate equipment inadequately rated for fault current
- .18 Design improvements/upgrades to rectify any observed Ontario Electrical Safety Code violations

.3 The Engineering Contractor shall provide the Arc Flash Risk Assessment evaluation table in Microsoft Excel format. The table shall include, but not limited to, the following:

.1 Building Code

.2 Building Name

.3 Address

.4 Floor

.5 Room number

.6 Equipment Name

.7 Working distance

.8 Arc Flash Incident Energy level

2.9 Label installation

.1 After the draft report, including a copy of the Arc Flash Hazard and Shock Warning Labels, is approved by the Region, the labels shall be installed in locations as described in the Standards.

.2 The Engineering Contractor shall arrange with the Region for access and install labels as indicated in the Arc Flash Risk Assessment report. They shall be installed prominently where personnel has to access the energized equipment. Bus or panel names on the label shall be the same as on the bus or panel enclosure and consistent with the bus or panel name on the Single Line Diagram.

.3 The label installer shall clean and otherwise prepare the surface for effective and permanent installation. The label installer shall be issued with a concise Arc Flash summary sheet outlining the panel names and the calculated incident energy level.

.4 Labels are required on:

.1 Power distribution equipment

.2 Control cabinets

.3 Distribution and lighting panels

.4 Equipment disconnects

.5 Equipment where access to energized electrics is required

.5 Labels are not required on:

.1 Enclosed equipment not required to be serviced while energized

.2 Motor terminal boxes

.3 120 volt receptacles

.4 Conduit fittings or pull boxes

.5 Lighting fixtures

.6 Equipment which is less than 50 volts and/or has an incident energy rating of less than 1.2 cal/cm^2 will require a shock hazard warning label (see Figure 2) to indicate that it is safe to enter under prescribed conditions.

.7 Where equipment is composed of multiple sections, cubicles or doors, warning labels shall be installed such that the hazard is readily observed upon opening of any enclosure door or panel.

.8 All equipment shall have a label containing information from the worse case scenario analysis.

.9 Units on label will be in millimeters and calories per centimeters squared. Distances shall be rounded to the nearest whole number. Incident energy level shall have decimals rounded to the nearest tenth.

.10 Arc Flash and Shock Hazard Labels shall be printed in a format to that shown in Figure 1. Labels will contain information including:

.1 The heading “ARC FLASH and SHOCK HAZARD”

.2 Incident Energy

.3 Working Distance

.4 Arc Flash Boundary

.5 Shock Hazard Potential

.6 Shock Insulation Class

.7 Limited Approach Boundary

.8 Restricted Approach Boundary

.9 Method of Arc Flash calculation

.10 Date of Study

.11 Firm Preparing the Study

.12 Name of Panel/Bus/Equipment

.13 Name of Upstream Protective Device

.11 Shock Hazard Labels shall be printed in a format to that shown in Figure 2. Labels will contain information including:

.1 The heading “SHOCK HAZARD”

.2 Shock Hazard Voltage

.3 Limited Approach Boundary

.4 Restricted Approach Boundary

.5 Shock Insulation Class

.6 Method of Arc Flash calculation

.7 Date of Study

.8 Firm Preparing the Study

.9 Name of Panel/Bus/Equipment

FIGURE 1: Arc Flash and Shock Hazard Label Standard

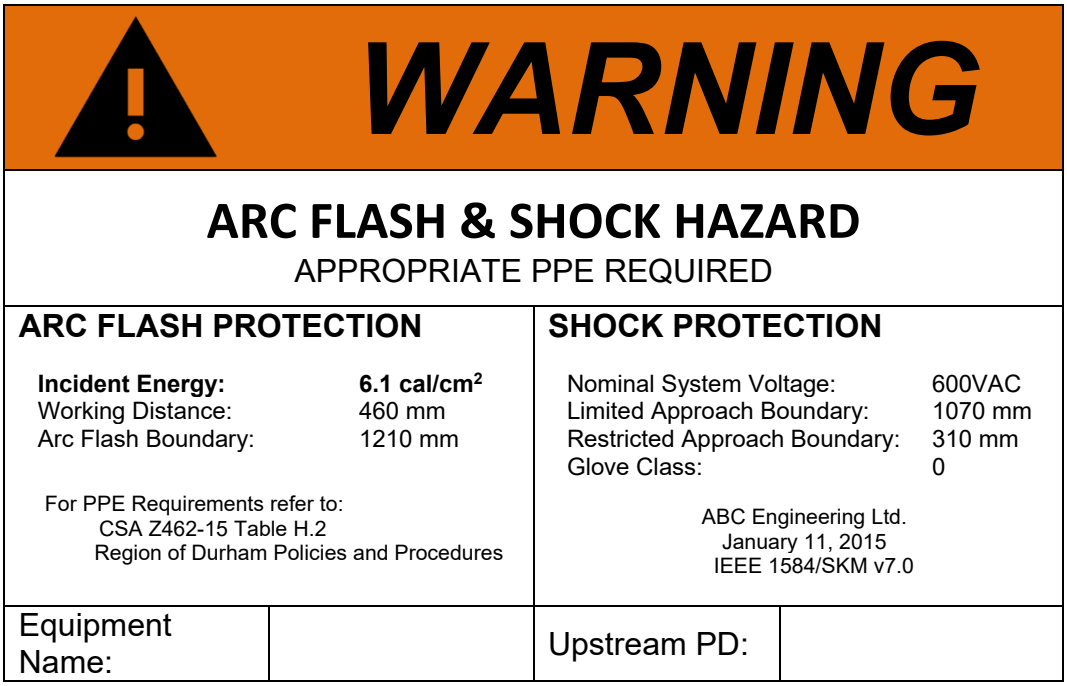
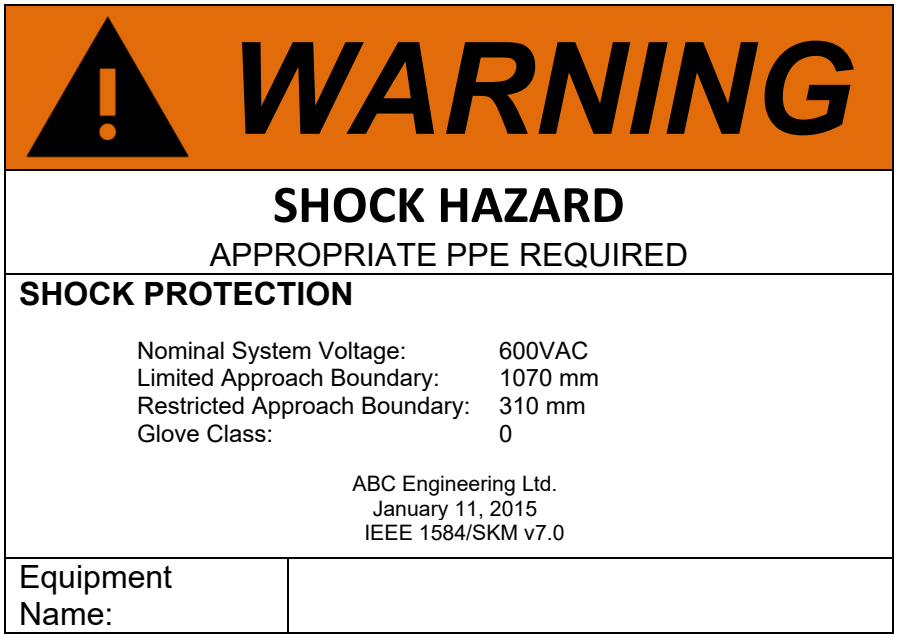


FIGURE 2: Shock Hazard Label Standard



.12 All labels will be compliant with CSA Z321, ANSI Z535 and the requirements of CSA Z462.

.1 Labels for equipment with an Incident Energy level of less than 40 cal/cm^2 will have an orange stripe and black lettering indicating “WARNING”.

.2 Labels for equipment with an Incident Energy level of 40 cal/cm^2 or above will have a red stripe and white lettering indicating “DANGER”.

.3 All other lettering shall be black.

.4 All labels shall be 4 in. x 6 in.

.5 Labels shall be printed in color and shall be moisture proof, adhesive backed, and UV resistant to avoid fading.

.6 Labels for outdoor equipment shall be durable, weatherproof (i.e. lamacoid) in Orange or Red as outlined above.

2.10 Final submittals

.1 The Engineering Contractor shall submit the following at the closure of the project:

.1 Final report in bound format as described above (1 hard copy, 1 PDF copy).

.2 Single Line Diagrams (E-SLD) (1 PDF copy in 11x17 format or larger where required (24 x 36 format), 1 electronic copy in AutoCAD format).

.3 Single Line Diagrams (E-SLD-ARC) for Arc Flash assessment (1 PDF copy in 11 x 17 format, 1 electronic copy in AutoCAD format).

.4 PDF File with all Labels in colour format.

.5 Arc Flash Risk Assessment evaluation table with incident energy values in MS Excel format.

.6 Copy of Arc Flash Software project file.

.7 Copy of all data collection files in CSV format.

.2 All final documentation shall be submitted as part of the Operating and Maintenance manuals for the facility.

2.11 Future availability

.1 To ensure that the Report and its findings remain valid over the next five years or until the next review, the Engineering Contractor shall:

.1 Maintain an electronic copy of the Arc Flash Risk Assessment Report for a period of not less than seven years from the report date.

.2 Maintain an electronic copy of the model and software files for a period of not less than seven years.

.3 Keep a copy of all data collection files with the above information.

.4 Provide the above information at no cost and in a timely manner on written request by the Region.

3 Execution

3.1 Field quality control

.1 The Qualified Engineer or his designate will inspect the work when complete to ensure that;

.1 All equipment modeled in the analysis has a correct label as indicated in the report.

.2 Warning Labels have been installed as per applicable standards.

.3 All required equipment has been included in the analysis.

.4 The Qualified Engineer will file a completion report that indicates that the equipment has been inspected and the scope of work has been completed per this Specification.

3.2 Verification by independent engineer

.1 The Region, at its discretion, shall appoint an Independent Engineer of their choice to review the System Model and Arc Flash Risk Assessment Report to verify the results and any recommendations.

.2 The Engineering Contractor will be advised by the Region should they exercise this option.

.3 The Engineering Contractor shall provide all software files and data collection records necessary to accommodate this.

.4 The Engineering Contractor shall correct any errors or omissions at its cost in a timely manner and re-submit the corrected Report and other deliverables.

APPENDIX 1

Appendix 1: Single Line Diagram Specifications – Required Component Information

Component	Arc Flash Info (CAD Layer: E-SLD-ARC)	ROW Info (CAD Layer: E-SLD)
Utility	Maximum Short Circuit Capacity Minimum Short Circuit Capacity Source Impedance	Source/Local Distribution Company (City) Service Size (Amps) Voltage/Phase Short Circuit Capacity
Transformer	Incident energy @ working distance Arc flash boundary % Impedance	kVA rating Primary Voltage Secondary Voltage Winding Configuration Grounding Configuration **Incident energy @ working distance**
Fusible Disconnect	Incident energy @ working distance Arc flash boundary	Disconnect Ampere Rating Fuse Type Fuse Rating **Incident energy @ working distance**
Disconnect		Disconnect Ampere Rating **Incident energy @ working distance**
Switch gear / Breaker	Incident energy @ working distance Arc flash boundary Short Circuit Interrupting Rating	Equipment name/label Voltage Amperage Phase Location Short circuit capacity **Incident energy @ working distance**
Bus	Incident energy @ working distance Arc flash boundary Short Circuit Withstand Rating	Ampere Rating Short circuit capacity **Incident energy @ working distance**

ARC FLASH RISK ASSESSMENT SPECIFICATION 2015

Appendix 1
Page 2 of 3

Component	Arc Flash Info (CAD Layer: E-SLD-ARC)	ROW Info (CAD Layer: E-SLD)
Wiring/Cables	Cable lengths Cable types/sizes	
Panels	Incident energy @ working distance Arc flash boundary Short Circuit Interrupting rating	Equipment name/label Voltage rating Ampere Rating Phase Location Short circuit capacity **Incident energy @ working distance**
Motors	Transient Reactance (Subtransient if a synchronous motor)	Equipment name/label Horsepower Location
Generator	Transient Reactance Subtransient Reactance	Equipment name/label kW Rating Voltage Amperage Phase Location
Solar Power Inverter	Incident energy @ working distance Arc flash boundary	Equipment name/label Voltage kW rating Phase Location **Incident energy @ working distance**
Major Equipment	Incident energy @ working distance Arc flash boundary Short Circuit Interrupting rating	Equipment name/label kW or HP Rating Voltage Rating Location **Incident energy @ working distance**

Component	Arc Flash Info (CAD Layer: E-SLD-ARC)	ROW Info (CAD Layer: E-SLD)
VFD's	Incident energy @ working distance Arc flash boundary Short Circuit Interrupting rating Regenerative or non-regenerative	Ampere Rating or HP **Incident energy @ working distance**
Battery Charging Systems	Number of Cells Amp hour capacity Short circuit capacity	Voltage rating of charger Ampere rating of charger

Symbols

Symbols for common components will be provided in the ROW drawing template.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

1.2 Related Requirements

.1 Section 25 01 00 – Controls

.2 Section 25 90 01 – Sequence of Operation

.3 Section 26 05 00 – General Electrical Requirements

.4 Section 26 05 05 – Basic Materials and Methods

.5 Section 26 50 00 – Lighting

1.3 References

.1 American National Standards / Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)

.2 Underwriter Laboratories of Canada (ULC)

.3 International Electro-Technical Commission

.4 International Organization for Standardization (ISO)

.5 National Electrical Manufacturers Association (NEMA)

.6 WD1 (R2005) - General Color Requirements for Wiring Devices.

.7 Underwriters Laboratories, Inc. (UL)

.1 916 – Energy Management Equipment.

.2 924 – Emergency Lighting

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

1.5 System description

.1 The Building Automation System (BAS) integrated Lighting Controls as defined under this section covers the following field devices/equipment:

.2 Digital Lighting Zone Controllers – Self-configuring, digitally addressable BAS integrated one (1), two (2) or three (3) relays controllers with 0-10 volt dimming control for electronic LED drivers.

.3 Digital Occupancy Sensors – Self-configuring, BAS integrated digitally addressable and self-calibrated occupancy sensors.

.4 Digital Switches – Self-configuring, BAS integrated digitally addressable pushbutton switches, dimmers, and scene managers.

.5 Digital Photosensors – BAS integrated single-zone closed loop and/or multi-zone open loop daylighting sensors, can provide switching and proportional dimming control for daylight harvesting based on pre-set room lighting levels.

.6 Digital Plug Load Controllers – Self-configuring, BAS integrated digitally addressable one or multi-relay controllers, specifically designed and cUL listed for use as a plug load control device.

.7 Isolated Relay Interfaces for mechanical and HVAC equipment – as defined in Section 25 01 00 – Controls.

1.6 Shop drawings

.1 Submit shop drawings in accordance with Section 26 05 00 – General Electrical Requirements and the requirements of Division 1.

.2 Shop drawing submission shall include:

.1 Composite wiring and/or schematic diagram of each lighting control circuit as proposed to be installed complete with BAS network integration (standard diagrams will not be accepted).

.2 Scale drawing for each area showing exact location of each sensor, lighting zone controller, digital switch and scene manager as applicable.

.3 Product Data: Catalog sheets, specifications and installation instructions.

.4 Include data for each device which:

.1 Indicates where sensor is proposed to be installed.

.2 Prove that the sensor is suitable for the proposed application.

1.7 Warranty

.1 Provide manufacturer's warranty as per Section 26 05 00 – General Electrical Requirements. BAS field devices' warranty shall equal warranty terms of overall BAS system.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Manufacturers

.1 Refer to Section 25 01 00 – Controls for approved system manufacturers.

.2 Alternate Manufacturers

.1 Any proposed substitutions shall be submitted in writing a minimum of five (5) working days prior to the tender closing date for review by the consultant. Proposed alternate products must be accompanied by a review of the specification and actual design drawings noting compliance on a line-by-line basis as pertain to sensor sensitivities, area coverage at proposed design elevations and equivalent device quantities required to meet the intended lighting control sequence as detailed in the "Lighting Controls Schedule". Alternate systems shall not be supplied and/or installed without written acceptance by the Consultant.

.2 The Contractor shall accept responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The Contractor shall provide complete engineered shop drawings

(including power, control and BAS network integration wiring) with deviations from the original design highlighted in an alternate color to the Consultant for review and approval prior to rough-in.

2.3 Single/dual relay wall switch occupancy sensors

.1 Manual-ON, Automatic-OFF dual technology (passive infrared and ultrasonic) wall switch occupancy sensor. Furnish the Company's model which suits the electrical system parameters, and accommodates the square-foot coverage and wattage requirement for each area (and type of lighting) controlled.

.2 Transmits detection status to BAS.

.3 CSA/UL listed product.

2.4 Digital wall or ceiling mounted occupancy sensor

.1 Wall or ceiling mounted dual technology digital (passive infrared and ultrasonic) occupancy sensor. Furnish the Company's system which accommodates the square-foot coverage requirements for each area controlled., which suit the lighting and electrical system parameters.

.2 Transmits detection status to BAS.

.3 CSA/UL listed product.

2.5 Digital wall switches

.1 Low voltage momentary pushbutton switches with 0-10 V dimming feature, programmable one (1), two (2), three (3), and multi-button configuration;

.1 Manual -ON, Manual -OFF.

.2 Dimming feature shall include visual indication of dimming step level.

.2 Transmits ON/OFF status to BAS.

.3 CSA/UL listed product.

2.6 Digital scene managers

.1 Scene Manager with LCD touch screen.

.2 Minimum four (4) programmable lighting scenes.

.3 Individual scenes may be locked to prevent unauthorized change.

.4 Local indication for "Eco" (ecological) running mode.

.5 Local indication for "Non-eco" (manual) running mode.

.6 One button switch reverts to "Eco" running mode.

.7 Transmits lighting scene parameters to BAS.

.8 Extended control capability for motorized shade and windows.

.9 CSA/UL listed product.

2.7 Lighting zone controllers

.1 Lighting Zone Controllers automatically bind the room lighting loads to BAS connected devices in the space and provide I/O control and communication interfacing with the BAS through free topology open network.

.2 Lighting Zone Controllers shall be provided to match the room lighting load, circuiting and control requirements as detailed in the "Lighting Controls Schedule".

.3 Lighting Zone Controller features shall include:

.1 On/Off function of multiple circuits within defined lighting zone.

.2 Auto ON/Off function of multiple circuits within defined lighting zone upon occupancy detection and/or BAS signal.

.3 Manual and/or Auto dimming function (0-10 V) of multiple circuits within defined lighting zone.

.4 Proportional auto dimming of multiple circuits upon daylight sensor detection to pre-set room lighting levels.

.5 The following dimming attributes may be selected:

.1 Establish preset level for each load from 0-100 %

.2 Set high and low trim for each load

.6 Occupancy-based control of plug loads within the space.

.4 CSA/UL listed product.

2.8 Digital photosensors

.1 Digital photosensors work with lighting zone controllers and BAS to provide automatic switching and proportional dimming daylight harvesting capabilities for any load type connected to a lighting zone.

.2 Closed loop photosensors measure the ambient light in the space and control a single lighting sub-zone.

.3 Open loop photosensors measure incoming daylight in the space, and are capable of controlling up to three lighting sub-zones. Photosensors shall be interchangeable without the need for rewiring.

.4 Digital photosensors include the following features:

.1 An internal photodiode that measures only within the visible spectrum, and has a response curve that closely matches the photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5 % for any wavelengths less than 400 nanometers or greater than 700 nanometers.

.2 Sensor light level range shall be from 1-10,000 footcandles (fc).

.3 The capability of switching one-third, one-half or all lighting ON and OFF, or raising or lowering lighting levels, for each controlled zone, depending on the selection of lighting zone controller and and associated light fixture circuiting.

.4 For switching daylight harvesting, the photosensor shall provide a deadband or a separation between the “ON Setpoint” and the “OFF Setpoint” that will prevent the lights from cycling after they turn off.

.5 For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a user-selectable minimum level.

.6 Optional programmable wall switch override to allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise and lower lighting levels for a selected period of time or cycle of occupancy.

.7 Local LED for visual indication of data transmission to the BAS.

.8 Local LED to indicate test or override mode.

.9 Adjustable head and a mounting bracket to accommodate multiple mounting methods and building materials. The photosensor may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox.

.5 Closed loop digital photosensors include the following additional features:

.1 An internal photodiode that measures light in a 100 degree angle, cutting off the unwanted light from bright sources outside of this cone.

.2 Automatic self-calibration, initiated from the photosensor or BAS.

.3 Automatically establishes setpoints following self-calibration.

.4 A sliding setpoint control algorithm for dimming daylight harvesting with a “Day Setpoint” and the “Night Setpoint” to prevent the lights from cycling.

.5 CSA/UL listed product.

.6 Open loop digital photosensors include the following additional features:

.1 An internal photodiode that measures light in a 60 degree angle cutting off the unwanted light from the interior of the room.

.2 Automatically establishes setpoints following calibration initiated from BAS.

.3 A proportional control algorithm for dimming daylight harvesting with a “Setpoint” to be maintained during operation.

.4 CSA/UL listed product.

2.9 Digital plug load controllers

.1 Single or Multi-Relay Digital Plug Load Controllers shall include the following features:

.1 20 Amp relays for on/off control of connected plug loads.

.2 cUL Listing for use with plug loads.

2.10 Isolated relay interfaces

.1 Refer to Section 25 01 00 – Controls for all mechanical and HVAC equipment controlled by BAS.

2.11 BAS software and programming

.1 Refer to Section 25 01 00 – Controls for BAS software and programming requirements.

3 Execution

3.1 Installation

.1 Do not install equipment until the following conditions can be maintained in spaces to receive equipment:

.1 Ambient temperature: 0 °C to 40 °C (32 °F to 104 °F).

.2 Relative humidity: Maximum 90 %, non-condensing.

.2 Provide detailed point to point wiring diagrams for every termination. Provide wire specifications and wire colors to simplify contactor termination requirements

.3 Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.

.4 Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.

.1 Adjust time delay so that controlled area remains lighted for 5 minutes after occupant leaves area.

.5 Provide written or computer-generated documentation on the commissioning of the system including room by room description including:

.1 Sensor parameters, time delays, sensitivities, and daylighting setpoints.

.2 Sequence of operation, (e.g. manual ON, Auto OFF. etc.)

.3 Load Parameters (e.g. blink warning, etc.)

.6 Re-commissioning – After thirty (30) days from occupancy re-calibrate all sensor time delays and sensitivities to meet the Owner's Project Requirements. Provide a detailed report to the Consultant / Owner of re-commissioning activity.

3.2 Factory commissioning

.1 Upon completion of the installation, the system shall be commissioned by the BAS manufacturer's factory authorized representative who will verify a complete fully functional system. Refer to Section 25 01 00 for additional requirements.

.2 The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.

.3 Upon completion of the system commissioning the factory-authorized BAS technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

1.2 Related requirements

.1 Section 26 05 00 – General Electrical Requirements

1.3 References

.1 CAN/CSA-C22.2 No.47 - Air-Cooled Transformers (Dry Type).

.2 CSA C9 - Dry-Type Transformers.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Scope

.1 Provide dry type distribution transformers as detailed herein and on drawings.

1.6 Shop drawings

.1 Submit shop drawings in accordance with Section 26 05 00 – General Electrical Requirements and the requirements of Division 1.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 All transformers shall be of one manufacturer. Acceptable Manufacturers: Schneider Electric, Eaton, Hammond, Rex, Delta, Bemag, or approved alternate.

.2 All material shall be specification grade, new and carry CSA approval or special inspection approval in accordance with Electrical Safety Authority requirements.

2.3 Transformers

.1 Type: ANN.

.2 Three (3) phase, 600 V input, 120/208 V output, 60 Hz. kVA rating as detailed on drawings.

.3 Custom wound three (3) phase, 600 V input, 230/400 V output, 60 Hz, Δ-Y. kVA rating as detailed on drawings.

.4 Voltage taps: standard, 2 x ±2.5 % (2 FCAN, 2 FCBN).

.5 Coil Windings: Copper

.6 Insulation: Class H (220 °C), 80 °C temperature rise.

.7 Average sound level: 60 dB or less

.8 Enclosure: CSA Type 2 (drip proof), removable metal front panel.

.9 Mounting: wall or floor, as detailed on drawings.

.10 Finish: ASA 61 baked grey powder coating.

3 Execution

3.1 Installation

.1 Mount dry type transformers up to 75 kVA floor or wall mounted as indicated on drawings. Coordinate installation with Consultant and structural trades with regards to proper load bearing.

.2 Mount dry type transformers above 75 kVA on floor. Provide 100 mm (4 in.) high concrete housekeeping pads under all floor mounted transformers

.3 Ensure adequate clearance (150 mm (6 in.) minimum to adjacent walls) is provided around transformers for ventilation.

.4 Install transformers in level upright position.

.5 Remove shipping supports only after transformer is installed and just before putting into service.

.6 Loosen isolation pad bolts until no compression is visible.

.7 Make primary and secondary connections in accordance with wiring diagram.

.8 Energize transformers after installation is complete.

End of section

1 General

1.1 Section includes

.1 Service Entrance Switchboard

1.2 Related requirements

.1 Contractor shall be responsible for co-ordinating this section with all related sections.

1.3 References

.1 Construction Standards, latest editions

.1 CSA C22.2 No. 31 Switchgear Assemblies.

.2 CSA C22.2 No. 244 Switchboards

.3 Ontario Electrical Safety Code

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Shop drawings

.1 Submit in accordance with the General Conditions and Section 01 33 00 – Submittal Procedures.

.2 Submit Shop Drawings for the following:

.1 Switchboard

.2 Metering

.3 Circuit Breakers

.4 Automatic Transfer Switch

.3 Submit approved manufacturer's shop drawings to local hydro distribution company for coordination and information regarding the type and quantity of CT's and PT's to be installed.

1.6 Quality assurance

.1 Acceptable Manufacturers:

.1 Eaton Cutler Hammer;

.2 Schneider Canada;

.3 Siemens; or

.4 Approved alternate.

.2 The switchboard design is based on a 600 VAC, 800 Amp rated, 1100 mm deep switchboard. Equipment meeting these specifications from any of the above manufacturers may be provided. The manufacturer of the switchboard shall also provide panel boards and distribution panels throughout the project.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Switchboards

.1 Structures

.1 Each complete assembly will be made up of a single cell unit which will be modern construction, fabricated from sheet steel of thickness in accordance with C.S.A. requirements, and reinforced where necessary to provide adequate strength. The units will be bolted together to form an enclosed, self-contained, self-supporting structure with necessary provision for ventilation. Hardware shall be good quality zinc chromate. Each section to be fully barriered internally from other sections.

.2 Short circuit bracing requirements shall be as specified on drawings.

.3 Switchboard shall be NEMA/CSA type 1 rated with drip hood, suitable for installation in a sprinklered room.

.2 Finish

.1 After fabrication each structure will be cleaned and finished with A.S.A. #61 light grey enamel.

.3 Bus Bars

.1 All bus bars shall be of high strength, high conductivity copper, and all bus joint hardware will be anticorrosive type, to provide maximum conductivity.

.2 Buses and connections will be designed so that the maximum temperature rise of any part will not exceed 65 °C over an ambient temperature of 40 °C.

.3 Neutral bus shall be full capacity bus.

.4 A continuous ground bus will be provided the length of the assembly, solidly bolted to the steel framework. Necessary cable terminals will be provided on the ground bus for the owner's ground connections. The ground bus will have a momentary rating equal to or greater than that of the apparatus in the assembly and in no case will the cross section area of the ground bus be less than ¼ in. x 2 in.

.4 Control Wiring

.1 Switchboard assembly will be complete with any necessary control wiring.

.5 Main Circuit Breaker

.1 The main circuit breaker shall be suitable for service entrance.

.2 Circuit breaker shall be rated 800 A frame size, 600 A trip and provided with electronic trip unit (LSI). Ground fault protection is not required at this time.

.3 Circuit breaker shall incorporate safety cover interlocks to prevent opening the cover with the breaker in the "on" position.

.4 Handles shall indicate the "on" and "off" position.

.5 Lock-out provisions shall be provided.

.6 Metering Provisions

.1 Obtain and install all necessary CT's and PT's required by the local supply authority to the supply authority's specifications.

.2 Provide a digital metering package within the switchboard assembly. The metering package shall be microprocessor based and provide the following functions:

.1 Digital display of phase voltages and currents, kVA, kVAR, kW, PF, Hz and the accumulated MWHR,

.2 Monitor and store minimum values of volts and PF,

.3 Monitor and store maximum values of Amps, kW, kVA, kVAR and kWD.

.4 Digital display of any stored value.

.5 Information stored in non-volatile memory.

.6 An Ethernet/IP communication connection port for future interface with the building energy management system.

.7 Meter shall be mounted in switchboard at approximately eye level (1,600 mm).

.7 Sub Distribution Sections

.1 Provide the number of sub-distribution sections as required to facilitate the number of sub-distribution overcurrent devices as specified on the drawings.

.8 Branch Circuit Breakers

.1 Provide molded case circuit breakers for branch distribution circuits.

.2 Provide electronic trip units for circuit breakers exceeding 200 Amp rating.

2.3 Automatic Transfer Switch

.1 Provide automatic transfer switch as part of main switchgear.

.2 Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.

.3 Fault-Current Closing and Withstand Ratings: UL 1008 WCR ratings must be specifically listed as meeting the requirements for use with protective devices at installation locations, under specified fault conditions.

Withstand and closing ratings shall be based on use of the same set of contacts for the withstand test and the closing test.

.4 Solid-State Controls: All settings should be accurate to +/- 2 % or better over an operating temperature range of - 40 to + 60 °C (- 40 to + 140 °F).

.5 Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

.6 Electrical Operation: Accomplished by a non-fused, momentarily energized solenoid or electric motor operator mechanism, mechanically and electrically interlocked in both directions (except that mechanical interlock is not required for closed transition switches).

.7 Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

.1 Switches using molded-case switches or circuit breakers, or insulated case circuit breaker components are not acceptable.

.2 Transfer switches shall be double-throw, electrically and mechanically interlocked, and mechanically held in the Source 1 and Source 2 positions.

.3 Main switch contacts shall be high pressure silver alloy. Contact assemblies shall have arc chutes for positive arc extinguishing. Arc chutes shall have insulating covers to prevent inter-phase flashover.

.4 Contacts shall be operated by a high-speed electrical mechanism that causes contacts to open or close within three electrical cycles from signal.

.5 The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function.

.6 Transfer switch shall be provided with flame retardant transparent covers to allow viewing of switch contact operation but prevent direct contact with components that could be operating at line voltage levels.

.8 Factory wiring: Transfer switch internal wiring shall be composed of pre-manufactured harnesses that are permanently marked for source and destination. Harnesses shall be connected to the control system by means of locking disconnect plug(s), to allow the control system to be easily disconnected and serviced without disconnecting power from the transfer switch mechanism

.9 Terminals: Terminals shall be pressure type and appropriate for all field wiring. Control wiring shall be equipped with suitable lugs, for connection to terminal strips.

.10 Enclosures: All enclosures shall be third-party certified for compliance to NEMA ICS 6 and UL 508, unless otherwise indicated:

.1 The enclosure shall provide wire bend space in compliance to the latest version of NFPA70, regardless of the direction from which the conduit enters the enclosure.

.2 Exterior cabinet doors shall provide complete protection for the system's internal components. Doors must have permanently mounted key-type latches. Bolted covers or doors are not acceptable.

.3 Transfer switches shall be provided in enclosures that are third party certified for their intended environment per NEMA requirements.

.11 Main contacts shall be rated for 600 VAC minimum.

.12 Transfer switches shall be rated to carry 100 % of rated current continuously in the enclosure supplied, in ambient temperatures of -40 to +60 °C (-40 to +140 °F), relative humidity up to 95 % (non-condensing), and altitudes up to 10,000 ft. (3,000 m).

.13 Manual Switch Operation: The power transfer mechanism shall include provisions for manual operation under load with the enclosure door closed. Manual operation may be electromechanical or mechanical, but must be coordinated with control function.

.14 Relay Signal: Control shall include provisions for addition of a pre-transfer relay signal, adjustable from zero (0) to sixty (60) seconds, to be provided based on equipment provided for the project.

.15 Neutral: Transfer switch shall be provided with a non-switched neutral pole. The neutral pole shall be of the same construction and have the same ratings as the phase poles.

.16 Automatic Transfer Switch Control Features

.1 The transfer switch control system shall be configurable in the field for any operating voltage level up to 600 VAC. Voltage sensing shall be monitored based on the normal voltage at the site. Systems that utilize voltage monitoring based on standard voltage conditions that are not field configurable are not acceptable.

.2 All transfer switch sensing shall be configurable from an operator panel or from a Windows XP or later PC-based service tool. Designs utilizing DIP switches or other electromechanical devices are not acceptable.

.3 The transfer switch shall provide a relay contact signal prior to transfer or re-transfer. The time period before and after transfer shall be adjustable in a range of zero (0) to sixty (60) seconds.

.4 The control system shall be designed and prototype tested for operation in ambient temperatures from - 40 °C to + 60 °C (- 40 to +140 °F). It shall be designed and tested to comply with the requirements of the noted voltage and RFI/EMI standards.

.5 The control shall have optically isolated logic inputs, high isolation transformers for AC inputs and relays on all outputs, to provide optimum protection from line voltage surges, RFI and EMI.

.6 The indicator panel LEDs shall display:

.1 Which source the load is connected to (Source 1 or Source 2)

.2 Which source or sources are available

.3 When switch is not set for automatic operation

.4 When the switch is in test/exercise mode

.7 The indicator shall have pushbuttons that allow the operator to activate the following functions:

.1 Activate pre-programmed test sequence

.2 Override programmed delays, and immediately go to the next operation

.3 Reset the control by clearing any faults

.4 Test all of the LEDs by lighting them simultaneously

.8 The alphanumeric digital display shall be vacuum fluorescent-type, clearly visible in both bright sunlight and no-light conditions over an angle of 120 °, and shall display the following:

.1 AC voltage for all phases, normal and emergency

.2 Source status: connected or not connected.

.9 The display panel shall be password-protected, and allow the operator to view and make adjustments:

.1 Set nominal voltage and frequency for the transfer switch

.2 Adjust voltage and frequency sensor operation set points

.3 Set up time clock functions

.4 Set up load sequence functions

.5 Enable or disable control functions including program transition

.6 View real-time clock data, operation log (hours connected, times transferred, failures) and service history

.10 Transfer Switch Control Panel: The transfer switch shall have a microprocessor-based control with a sealed membrane panel incorporating pushbuttons for operator-controlled functions, and LED lamps for system status indicators. Panel display and indicating lamps shall include permanent labels.

.11 Control Functions: Functions managed by the control shall include:

.1 Software adjustable time delays:

.1 Engine start (prevents nuisance genset starts in the event of momentary power fluctuation): zero (0) to one hundred and twenty (120) seconds (default three (3) sec)

.2 Transfer normal to emergency (allows genset to stabilize before load is transferred): zero (0) to one hundred and twenty (120) seconds (default three (3) sec)

.3 Re-transfer emergency to normal (allows utility to stabilize before load is transferred from genset): zero (0) to thirty (30) minutes (default three (3) sec)

.4 Engine cooldown: zero (0) to thirty (30) minutes (default ten (10) min)

.5 Programmed transition: zero (0) to sixty (60) seconds (default three (3) sec)

.2 Undervoltage sensing: three-phase normal, three-phase emergency source.

.3 Over-voltage sensing: three-phase normal, three-phase emergency source.

.4 Over/under frequency sensing:

.1 Pickup: +/- 5 to +/-20 % of nominal frequency (default 10 %)

.2 Dropout: +/-1% beyond pickup (default 1 %)

.3 Dropout time delay: 0.1 to 15.0 seconds (default five (5) sec)

.4 Accurate to within +/- 0.05 Hz

.5 Voltage imbalance sensing:

.1 Dropout: 2 to 10 % (default 4 %)

.2 Pickup: 90 % of dropout

.3 Time delay: 2.0 to 20 seconds (default five (5) sec)

.6 Phase rotation sensing:

.1 Time delay: 100 msec

.7 Loss of single-phase detection:

.1 Time delay: 100 msec

.12 Control features shall include:

.1 Programmable genset exerciser: A field-programmable control shall periodically start and run the generator with or without transferring the load for a preset time period, then re-transfer and shut down the generator after a preset cool-down period.

.2 In event of a loss of power to the control, all control settings, real-time clock setting and the engine start-time delay setting will be retained.

.3 The system continuously logs information including the number of hours each source has been connected to the load, the number of times transferred, and the total number of times each source has failed. An event recorder stores information, including time and date-stamp, for up to fifty (50) events.

.4 Re-Transfer Inhibit Switch: Inhibits automatic re-transfer control so automatic transfer switch will remain connected to emergency power source as long as it is available regardless of condition of normal source.

.5 Transfer Inhibit Switch: Inhibits automatic transfer control so automatic transfer switch will remain connected to normal power source regardless of condition of emergency source.

.13 Control Interface

.1 Provide one set Form C auxiliary contacts on both sides, operated by transfer switch position, rated 10 amps 250 VAC.

.14 Engine Starting Contacts

.1 One isolated and normally closed pair of contacts rated 10 A at 32 VDC minimum.

.17 BAS monitoring integration

.1 Coordinate with BAS system provider for interconnecting wiring between ATS and BAS system for the following signals as a minimum:

.1 Utility Source Available

.2 Generator Source Available

.3 Switch position Utility

.4 Switch position Generator

.18 Solar PV integration

.1 Coordinate with Solar PV system provider to interconnect permissive signal from ATS to Solar PV control. Solar PV shall only be connected when utility power is connected.

3 Execution

3.1 General

.1 The low voltage switchboard manufacturer shall install the supply authority CT's and PT's. This division shall coordinate between the supply authority and the switchboard manufacturer to ensure that the supply authority components are incorporated into the switchboard.

3.2 Installation

.1 Installation on site to be as per manufacturers instructions and recommendations.

.2 A manufacturer's representative shall visit the site to inspect the installation and provide on site commissioning and troubleshooting of the switchboard devices.

.3 All equipment to be mounted, plumbed true.

.4 Provide a 4 in. concrete housekeeping pad for the switchboard.

.5 Provide drip proof shields on all panels installed in sprinklered areas.

.6 Provide Lamacoid nameplates mechanically fastened to the electrical equipment to identify each device of the switchboard. Letter size to be as described in Section 26 05 00 – General Electrical Requirements.

3.3 Field quality control

.1 Provide spot checks on all terminations as directed by the Consultant. Tighten all loose

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

1.2 Related requirements

.1 Section 26 05 00 – General Electrical Requirements

1.3 References

.1 CSA-C22.2 No. 5 - Moulded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

.2 CSA C22.2 No.29 - Panelboards and Enclosed Panelboards.

.3 CSA CAN/CSA-C22.2 NO. 1010.1-92 - Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use

.4 CSA C22.2 No.144 - Ground Fault Circuit Interrupters.

.5 Section 26 43 13 – Transient Voltage Surge Suppression.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Scope

.1 Provide panelboards complete with moulded case circuit breakers and other accessories as detailed herein and on drawings.

.2 Provide panelboard enclosed branch circuit metering and multi-point data acquisition system.

.3 Coordinate the required short circuit ratings with the results of the Arc Flash Risk Assessment Study per Section 26 05 73 – Arch Flash Risk Assessment.

.4 Provide transient voltage surge suppression devices for distribution panels and panelboards as detailed on drawings.

1.6 Shop drawings

.1 Submit shop drawings in accordance with Section 26 05 00 – General Electrical Requirements and the requirements of Division 1.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 All panelboards, moulded case circuit breakers and branch multi-point metering shall be of one manufacturer.

.2 Acceptable Manufacturers are: Eaton (Pow-R-Line C series with PXMP multipoint metering for 400 V and 600 V panels, P1a series with PXBCM Advanced multipoint metering for 208 V panels), Equivalent product from Schneider Electric or Siemens will be accepted, or approved alternate.

.3 All material shall be specification grade, new and carry CSA approval or special inspection approval in accordance with the requirements of the Electrical Safety Authority.

2.3 Panelboards

.1 Refer to drawings for specific details pertaining to panelboards: mains rating, voltage, main lug or main breaker, flush or surface mounting, number of circuits, number of energy metered branches, number and size of branch circuit breakers.

.2 Install circuit breakers, current transformers and metering modules in panelboards before shipment.

.3 In addition to CSA requirements manufacturer's nameplate must show fault current that panel including breakers has been built to withstand.

.4 208 VAC panelboards: bus and circuit breakers rated for short circuit interrupting capacity as per result of power system study calculations Section 26 05 73 – Arch Flash Risk Assessment. Minimum 10 kA (rms symmetrical) interrupting capacity or as indicated in panel schedules.

.5 400 VAC panelboards: bus and circuit breakers rated for short circuit interrupting capacity as per result of power system study calculations Section 26 05 73 – Arch Flash Risk Assessment. Minimum 18 kA (rms symmetrical) interrupting capacity or as indicated in panel schedules.

.6 600 VAC panelboards: bus and circuit breakers rated for short circuit interrupting capacity as per result of power system study calculations Section 26 05 73 – Arch Flash Risk Assessment. Minimum 18 kA (rms symmetrical) interrupting capacity or as indicated in panel schedules.

.7 600VAC Service entrance switchboard: bus and circuit breakers rated for short circuit interrupting capacity as per result of power system study calculations Section 26 05 73 – Arch Flash Risk Assessment. Minimum 35 kA (rms symmetrical) interrupting capacity.

.8 Sequence phase bussing with odd numbered breakers on left and even on right, with each breaker identified by permanent number identification as to circuit number and phase.

.9 Provide two keys for each panelboard and key panelboards alike.

.10 Copper bus with neutral of same ampere rating as mains. Provide 200 % rated neutral where noted on drawings.

.11 Mains: suitable for bolt-on circuit breakers.

.12 Trim with concealed front bolts and hinges.

.13 Trim and door finish: baked grey enamel.

.14 Panelboard Accessories: Refer to drawings for details regarding any required panelboard accessories (sub feed lugs, feed through lugs, contactor on mains, etc.).

2.4 Moulded case circuit breakers

.1 Bolt-on moulded case circuit breaker: quick- make, quick-break type, for manual and automatic operation with temperature compensation for 40 °C ambient.

.2 Common-trip breakers: with single handle for multi-pole applications.

.3 Circuit breakers for 208 V panelboards to have minimum 10 kA symmetrical rms interrupting capacity rating and for 400 V and 600 V panelboards to have minimum 18 kA symmetrical rms interrupting capacity rating unless noted otherwise on panel schedules.

.4 Circuit breakers for main service entrance MEDP 600 V to have minimum 25 kA symmetrical rms interrupting capacity rating.

.5 Where series rated circuit breakers are utilized, they shall be manufacturer tested and listed per cUL standard test methods. Circuit breakers to be applied following manufacturer's guidelines and accepted best practice.

.6 Circuit breakers shall have thermal and magnetic tripping in panelboards except as indicated otherwise. (Circuit breakers rated 90 A or more shall have adjustable magnetic setting; circuit breakers rated 250 A or more shall have adjustable electronic trip settings).

.7 Main breaker: separately mounted on top or bottom of panel to suit cable entry. When mounted vertically, down position should open breaker.

.8 Lock-on devices to be provided for exit signs, security system, and telecommunication equipment. Provide additional devices where noted on drawings.

2.5 Transient voltage surge suppression

.1 All panelboards shall be supplied complete with integral transient voltage suppression units of the same manufacture as panelboard and panelboard components.

.2 Refer to Section 26 43 13 – Transient Voltage Surge Suppression.

3 Execution

3.1 Panelboards

.1 Locate panelboards as indicated and mount securely, plumb, true and square, to adjoining surfaces.

.2 Install surface mounted panelboards on plywood backboards. Where practical, group panelboards on a common backboard.

.3 Mount panelboards to height specified in Section 26 05 00 – General Electrical Requirements or as indicated.

.4 Provide a spare 35 mm (1¼ in.) EMT raceway into accessible ceiling space from each recessed panel. Provide nylon pull string in raceway and cap open end.

.5 Connect loads to circuits. Complete circuit directory with typewritten legend showing location and load of each circuit.

.6 Provide drip proof shields on all panelboards installed in sprinklered areas.

.7 Provide EEMAC 12 enclosures for panelboards located within electrical rooms and non-sprinkled general areas. Provide EEMAC 2 enclosures with protective drip-proof hood in sprinklered locations.

.8 Provide lamacoid nameplate mechanically fastened to identify each panel. Letter size to be as described in Section 26 05 00 – General Electrical Requirements.

3.2 Circuit breakers

.1 Ensure all circuit breakers mounted in panelboard have the specified interrupting capacity required for that piece of equipment.

3.3 Panelboard TVSS devices

.1 Transient voltage surge suppressors shall be installed within the panelboards at the manufacturer’s factory.

.2 A direct bus bar connection shall be used to mount the TVSS component to the panelboard bus bar to reduce the impedance of the shunt path.

End of section

1 General

1.1 Section includes

.1 This section covers requirements for the design and installation of a turnkey solution, including the Engineering, Procurement and Construction of a rooftop Photovoltaic (PV) system at the Seaton Paramedics and Training Facility.

.2 The contractor shall hire a PV system provider to provide a full system based on this specification and associated references as part of this contract.

.3 The Photovoltaic (PV) system shall include, but not limited to:

.1 PV modules;

.2 PV module mounting system;

.3 PV inverters;

.4 Utility Net-Metering;

.5 Monitoring system; and

.6 All interconnected wiring and devices up to and including the building electrical distribution system tie in point indicated in the contract drawings.

1.2 Related requirements

.1 Section 26 05 00 – General Electrical Requirements

.2 Section 26 05 05 – Basic Materials and Methods

.3 Section 26 43 13 – Transient Voltage Surge Suppression

1.3 Reference standards

.1 Ontario Electrical Safety Code, 27th Edition, 2018.

.2 CSA C22.2 No. 0.19 - Requirements for Service Entrance Equipment 2010.

.3 CSA C22.2 No. 107.1 - Power Conversion Equipment 2016.

.4 CSA C22.2 No. 257 - Interconnecting Inverter-Based Micro-Distributed Resources to Distribution Systems 2006 (R2015).

.5 CSA C22.2 No. 269.1 - Surge Protective Devices - Type 1 - Permanently Connected 2017.

.6 IEC 61215-1 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 1: Test Requirements 2016.

.7 IEC 61215-1-1 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 1-1: Special Requirements for Testing of Crystalline Silicon Photovoltaic (PV) Modules 2016.

.8 IEC 61215-1-2 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 1-2: Special Requirements for Testing of Thin-Film Cadmium Telluride (CDTE) Based Photovoltaic (PV) Modules 2016.

.9 IEC 61215-1-3 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 1-3: Special Requirements for Testing of Thin-Film Amorphous Silicon Based Photovoltaic (PV) Modules 2016.

.10 IEC 61215-1-4 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 1-4: Special Requirements for Testing of Thin-Film $Cu(In,GA)(S,Se)_2$ Based Photovoltaic (PV) Modules 2016.

.11 IEC 61215-2 - Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval - Part 2: Test Procedures 2016.

.12 IEEE 1547 - Standard for Interconnecting Distributed Resources with Electric Power Systems 2008 (Amended 2014).

.13 NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2018.

.14 UL 489B - Outline of Investigation for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures for Use with Photovoltaic (PV) Systems Current Edition, Including All Revisions.

.15 UL 1449 - Standard for Surge Protective Devices Current Edition, Including All Revisions.

.16 UL 1699B - Outline of Investigation for Photovoltaic (PV) DC Arc-Fault Circuit Protection; Current Edition Current Edition, Including All Revisions.

.17 UL 1703 - Flat Plate Photovoltaic Modules and Panels Current Edition, Including All Revisions.

.18 UL 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources Current Edition, Including All Revisions.

.19 UL 2579 - Low-Voltage Fuses - Fuses for Photovoltaic Systems Current Edition, Including All Revisions.

1.4 Administrative requirements

.1 Coordination:

.1 Coordinate work to avoid placement of ductwork, piping, equipment or other potential obstructions within spaces dedicated for photovoltaic system components.

.2 Coordinate arrangement of electrical equipment with dimensions and clearance requirements of actual equipment to be installed.

.3 Roof-Mounted Arrays: Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.

.4 Notify Consultant of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

.2 Preinstallation Meeting: Convene one week prior to commencing work of this section; require attendance of affected installers. Include adequate instruction on electrical hazards associated with photovoltaic systems and appropriate safety procedures to be followed.

.3 LEED Certification: Prepare and submit documentation as required for Owner to achieve LEED renewable energy credits.

.1 Include copies of documentation with submittals.

.4 Utility Interconnection:

.1 Coordinate with Elexicon Energy (Olivia Baudais, (905) 427-9870 x 3207) to complete Connection Impact Assessment (CIA) application, Offer to Connect (OTC) and pay any associated fees.

.2 Prepare and submit documentation as required for securing utility interconnection agreement between Owner and Supply Authority.

.1 Include copies of documentation with submittals.

.3 Preinstallation Meeting: Convene one (1) week prior to commencing work of this section to review interconnection requirements and details with Supply Authority representative.

.4 Coordinate with Supply Authority to provide utility metering suitable for system requirements.

.5 Arrange for inspections and secure permits necessary to obtain Supply Authority approval of system.

1.5 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Design Documents: Prepare and submit information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, details, and description of operation.

.4 Product Data: Provide manufacturer's standard catalog pages and data sheets for each product. Include ratings, configurations, standard wiring diagrams, outline and support point dimensions, finishes, weights, service condition requirements, and installed features.

.5 Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, attachment locations and details, and proposed size, type, and routing of conduits and cables. Include system interconnection schematic diagrams showing factory and site connections.

.1 Include proposed locations of roof penetrations and proposed methods for sealing.

.6 Design Data:

.1 Include structural calculations, authenticated by professional engineer licensed to practice in province of the work, for equipment and mounting system.

.2 Include electrical calculations for array and associated equipment other than basis of design products and configuration.

.7 Certify that products of this section meet or exceed specified requirements.

.8 Certify that work of this section does not void roof warranty.

.9 Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.

.10 Manufacturer’s detailed site testing procedures.

.11 Manufacturer's detailed startup procedures.

.12 LEED credit documentation.

.13 Utility interconnection documentation.

.14 Source quality control test reports.

.15 Site quality control test reports.

.1 Include manufacturer's site reports.

.16 Structural designer's qualification statement.

.17 Electrical designer's qualification statement.

.18 Manufacturer's qualification statement.

.19 Installer's qualification statement.

.20 Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

.1 Include contact information for entity that will be providing contract maintenance and trouble call-back service.

.21 Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

.22 Maintenance contracts.

.23 Project Record Documents: Record actual locations of system components, installed circuiting arrangements and routing, and final equipment settings.

.24 Software: One (1) copy of software provided under this section.

.25 Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

.1 See Section 01 78 00 – Closeout Submittals for additional provisions.

.2 Extra Photovoltaic Modules: Two (2).

1.6 Quality assurance

.1 Comply with CSA C22.1.

.2 Comply with Supply Authority requirements for interconnection.

.3 Maintain at project site one copy of each referenced document that prescribes execution requirements.

.4 Structural Designer Qualifications: Professional engineer licensed to practice in the province of Ontario.

.5 Electrical Designer Qualifications: Professional engineer licensed to practice in the province of Ontario, experienced in design of photovoltaic systems.

.6 Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

.7 Installer Qualifications: Company specializing in performing work of this section with minimum five (5) years documented experience with photovoltaic systems of similar size, type, and complexity.

.1 Licensed in Ontario to install photovoltaic systems.

.2 Manufacturer's authorized installer.

.3 Supervisor: CSA certified Construction Electrician (NOC 7241) Solar Photovoltaic (PV) Systems Personnel and/or North American Board of Certified Energy Practitioners (NABCEP) certified PV Installer or three years' experience supervising installation of photovoltaic systems.

.4 Installer Personnel: CSA certified Construction Electrician (NOC 7241) Solar Photovoltaic (PV) Systems Personnel or at least 2 years of experience installing photovoltaic systems.

.8 Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.

.1 Contract maintenance office located within 80 km of project site.

.9 Product Listing Organization Qualifications: Organization recognized by Standards Council of Canada and acceptable to authorities having jurisdiction.

1.7 Delivery, storage, and handling

.1 Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

1.8 Warranty

.1 See Section 01 78 37 – Extended Warranties for additional warranty requirements.

.2 Specified warranties indicate minimum requirements. Provide additional warranties or extended warranty periods, where required, to qualify for rebate and incentive programs.

.3 Photovoltaic Modules:

.1 Provide minimum five (5) year manufacturer warranty starting from date of Substantial Performance covering repair or replacement due to defective materials or workmanship.

.2 Provide manufacturer warranty guaranteeing minimum 90 % of rated power output for ten (10) years starting from date of Substantial Performance and minimum 80 % of rated power output for twenty (20) years starting from date of Substantial Performance.

.4 Photovoltaic Module Mounting System: Provide minimum ten (10) year manufacturer warranty starting from date of Substantial Performance covering repair or replacement due to defective materials or workmanship.

.5 Photovoltaic Combiner Boxes: Provide minimum five (5) year manufacturer warranty starting from date of Substantial Performance covering repair or replacement due to defective materials or workmanship.

.6 Photovoltaic Inverters: Provide minimum five (5) year manufacturer warranty starting from date of Substantial Performance covering repair or replacement due to defective materials or workmanship.

.7 Charge Controllers: Provide minimum five (5) year manufacturer warranty starting from date of Substantial Performance covering repair or replacement due to defective materials or workmanship.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 System integrators

.1 Oxford Energy;

.2 Carmanah Technologies;

.3 S2E Technologies;

.4 Solar Provider Group; or

.5 Approved alternate.

2.3 Manufacturers

.1 Photovoltaic Modules, Crystalline Silicon:

.1 Hanwha;

.2 CanadianSolar;

.3 Panasonic; or

.4 Approved alternate.

.2 Photovoltaic Module Mounting System:

.1 KB Racking;

.2 Polar Racking; or

.3 Approved alternate.

.3 Photovoltaic Inverters:

.1 Fronius; or

.2 Approved alternate.

.4 Monitoring System:

.1 Fronius;

.2 Schneider Electric;

.3 Draker Corp.; or

.4 Approved alternate.

.5 Source Limitations: For each type of component, furnish products produced by a single manufacturer and obtained from a single supplier.

2.4 Photovoltaic system requirements

.1 Provide complete photovoltaic system consisting of photovoltaic modules and associated balance of system components necessary for connection to facility electrical system.

.2 System Description:

.1 Photovoltaic array is roof-mounted in locations as indicated on Drawings.

.2 Orientation of array is as indicated on Drawings.

.3 Photovoltaic DC system is bonded but not tied into building grounding system.

.4 System includes interconnection with utility grid (grid-tied system).

.1 Utility metering configuration: Net metering.

.5 System does not include battery storage system.

.6 System does not include engine generator.

.7 System includes DC system surge protection.

.8 System includes monitoring system.

.3 Capacity:

.1 Minimum Expected Annual Energy Production: 69.7 MWh per year, as calculated by HelioScope PV design software (www.helioscope.com) or approved alternate.

.2 Total Nominal Rated Power Output of Array: Equal to or greater than 56, 780W DC.

.3 Nominal Rated Power Output of Individual Modules: Equal to or greater than 340W DC.

.4 System Nameplate Rating: Equal to or greater than 48,000W AC

.4 Size:

.1 Array: Designed to fit within area designated on Drawings.

.2 Individual Modules: Size is not critical.

.5 Appearance:

.1 Only systems with similar appearance to basis of design system will be considered.

.2 Arrange array such that modules are aligned with uniform spacing.

.3 Make no alterations affecting appearance of building exterior or interior without approval of Consultant.

.4 Final determination of acceptable appearance is by Consultant.

.6 Provide photovoltaic system and associated components suitable for wind loads, snow loads, seismic loads, and other structural design considerations of installed location.

.1 Include structural calculations demonstrating compliance with submittals.

.7 Provide photovoltaic system and associated components suitable for continuous operation under service conditions at installed location.

.1 Altitude: 84 m.

.2 Ambient Temperature: Between -40 and 40 °C.

.8 Provide products listed, classified, and labeled as suitable for purpose intended.

.9 Unless specifically indicated to be excluded, provide required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for complete operating system.

.10 DC Arc Fault Circuit Protection: Provide DC photovoltaic arc-fault protection devices listed as complying with UL 1699B as required for compliance with CSA C22.1.

.11 Rapid Shutdown of Photovoltaic Systems on Buildings: Provide listed equipment arranged to provide rapid shutdown in accordance with CSA C22.1.

.12 Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and CSA C22.1.

.13 Arrange array to provide adequate access to rear of string(s) for maintenance.

.14 Arrange array to minimize shading during peak production periods.

.15 Roof-Mounted Arrays:

.1 Arrange array such that normal roof drainage is not affected.

.2 Arrange array to maintain required safety clearances from edges of roof as indicated.

.3 Arrange array to maintain access and clearance requirements for other roof-mounted equipment.

.4 Arrange array to avoid spanning of expansion joints.

2.5 Photovoltaic modules

.1 Acceptable Module Types: Crystalline silicon modules complying with specified requirements will be considered for this project.

.2 General Requirements:

.1 Photovoltaic Modules: Factory assembled; consisting of photovoltaic cells, frame, junction box, cables for series connection, and bypass diodes for shade tolerance; rated for 1000 V DC; complying with IEC 61215-1 and IEC 61215-2 and listed as complying with UL 1703 and CSA C22.2 No. 107.1.

.2 Crystalline Silicon Photovoltaic Modules: Comply with IEC 61215-1-1.

.3 Frame: Anodized aluminum.

.4 Factory-Installed Junction Box: Weatherproof, with factory-installed terminals and bypass diodes.

.5 Factory-Installed Cables: Type USE-2 or listed photovoltaic (PV) wire with polarized locking connectors.

.6 Unless otherwise indicated, specified module performance characteristics are rated under Standard Test Conditions (STC).

.7 Power Rating Tolerance: Plus 10 or minus 5 %.

.1 Include flash test data for each module with source quality control reports to demonstrate compliance.

.3 Basis of Design: Hanwha Q-Peak Duo L-G8 or approved alternate.

2.6 Balance of system components

.1 Photovoltaic Module Mounting System:

.1 Provide complete mounting system compatible with modules to be installed and suitable to properly install them in location indicated, including necessary hardware and accessories.

.2 Support Structure and Associated Hardware Materials: Use aluminum, galvanized steel, or stainless steel.

.3 Roof-Mounted Arrays:

.1 Acceptable System Types: Non-penetrating, ballasted system.

.2 Provide system compatible with roof at installed location.

.3 Module Tilt Angle: As required to provide maximum energy production for installed location. 10 ° minimum.

.4 Provide minimum clearance of 76 mm between roof and module for air circulation and drainage.

.2 Photovoltaic Inverters:

.1 Provide inverter(s) as indicated or as required for connection of photovoltaic array DC system to AC system indicated.

.2 Inverters: Suitable for requirements of connected array; output configuration compatible with connected system; listed as complying with UL 1741 and CSA C22.2 No. 107.1; furnished with the following features:

.1 Maximum power point tracking (MPPT).

.2 LCD display.

.3 Integral AC disconnect.

.4 Integral DC disconnect.

.5 Integral DC ground fault detection and interruption (GFDI).

.6 Communications Interface: As required for connection to system indicated.

.7 Fused string input terminals.

.3 Grid-Tied Inverters: Comply with IEEE 1547 and CSA C22.2 No. 257, including over/under grid voltage and frequency protection, and anti-islanding protection to automatically disconnect upon loss of utility power and to remain disconnected until utility power restoration has been maintained for five minutes.

.4 Total Harmonic Distortion: Less than five percent.

.5 Enclosure Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:

.1 Outdoor Locations: Type 3R or 4X.

.3 Enclosed Switches, in Addition to Requirements of Section 26 05 00 – General Electrical Requirements:

.1 Switches for DC System: Rated for 600 V DC.

.2 Switches Connected to Supply Side of Service Disconnecting Means: Listed and labeled as suitable for use as service equipment according to CSA C22.2 No. 0.19.

.4 Surge Protective Devices:

.1 Surge Protective Devices for DC System:

.1 Rated for 1,000 V DC.

.2 Listed and labeled as complying with CSA C22.2 No. 269.1, Type 1.

.3 Surge Current Rating: Not less than 50 kA per mode.

.4 CSA C22.2 No. 269.1 Nominal Discharge Current (I-n): 20 kA.

.5 Fuses:

.1 Fuses for DC System: Rated for 1,000 V DC.

.2 Fuses for Protection of Photovoltaic Strings and Arrays: Photovoltaic fuses listed as complying with UL 2579.

.6 Monitoring System:

.1 Provide system to monitor photovoltaic system performance including sensors, dataloggers, connections, software, equipment and accessories necessary for complete operating system.

.2 System communications interfaces to be wired or wireless, with compatible interconnected components.

.1 Provide suitable raceway, minimum 21 mm trade size, for required wired connections.

.3 System to monitor and record, in fifteen (15) minute intervals:

.1 Inverter status.

.2 Instantaneous power (kW).

.3 Cumulative energy production (kWh).

.4 Irradiation.

.5 Ambient temperature.

.6 Module cell temperature.

.7 Wind speed and direction.

.8 Current monitoring for individual strings.

.4 System real-time and historical data to be accessible from the following locations:

.1 Personal computer(s), via internet connection.

.2 Remote personal display(s), quantity and location as indicated on Drawings.

.3 Remote public display(s), quantity and location as indicated on Drawings.

.5 System to provide alarm notification via e-mail or instant message.

.6 System to be compatible with third party monitoring service to be selected by Owner.

2.7 Source quality control

.1 Factory test the following products to verify operation and performance characteristics. Include test reports with submittals.

.1 Photovoltaic modules.

.2 Photovoltaic inverters.

3 Execution

3.1 Examination

.1 Verify that site measurements are as indicated.

.2 Verify that ratings and configurations of system components are consistent with indicated requirements.

.3 Verify that mounting surfaces are ready to receive system components.

.4 Verify that conditions are satisfactory for installation prior to starting work.

3.2 Preparation

.1 Use open circuiting, short circuiting, or opaque covering to disable modules, array or portions of array prior to installation and service.

.2 Roof-Mounted Arrays: Protect roof and adjacent roof-mounted items from damage.

3.3 Installation

.1 Install products in accordance with manufacturer's instructions.

.2 Install photovoltaic system in accordance with CSA C22.1.

.3 Provide required support and attachment in accordance with reviewed shop drawings.

.4 Provide required seismic controls in accordance with Section 26 05 05 – Basic Materials and Methods.

.5 Mount equipment such that highest position of operating handle for circuit breakers or switches does not exceed 2,000 mm above floor, ground, or working platform.

.6 Circuiting Requirements:

.1 Wiring Methods:

.1 Unless otherwise indicated, use exposed module factory-installed cables (not routed inside building) for module interconnections.

.2 Unless otherwise indicated, use exposed type RPVU conductor cable (not routed inside building) for wiring between string(s).

.3 Secure exposed cables in accordance with CSA C22.1. Where possible, conceal behind array.

.4 Install cables in suitable raceway where readily accessible or where required by authority having jurisdiction.

.5 Use suitable twist-on insulated spring connectors, mechanical connectors, or compression connectors for photovoltaic circuit splices and taps.

.2 Photovoltaic DC System Conductor Colour Code:

.1 DC System:

.1 Positive: Red.

.2 Negative: Black.

.3 Maintain separation of photovoltaic and non-photovoltaic circuits in accordance with CSA C22.1.

.7 Grounding and Bonding Requirements:

.1 Ensure that there is only one AC System bonding connection between grounding system and grounded/neutral conductor, including external connections and connections internal to equipment.

.2 Grounded DC Systems: Ensure that there is only one point of system grounding connection to grounded conductor, including external connections and connections internal to equipment.

.3 Provide auxiliary electrodes for photovoltaic array grounding in accordance with CSA C22.1.

.8 Identification Requirements:

.1 Colour for Photovoltaic System Identification Nameplates and Labels: White text on red background, unless otherwise required by CSA C22.1 or authorities having jurisdiction.

.2 Use identification nameplate or means of identification acceptable to authority having jurisdiction to identify presence of multiple power sources and location of main service disconnecting means and each photovoltaic system disconnecting means. Locate at main service disconnecting means and at each photovoltaic system disconnecting means. Verify format and descriptions with authorities having jurisdiction.

.3 Use identification nameplate to identify each photovoltaic system disconnecting means with text "PV SYSTEM DISCONNECT".

.4 Use identification nameplate or identification label to identify systems equipped with rapid shutdown and associated rapid shutdown switch(es). Format, descriptions, and locations to comply with CSA C22.1 and requirements of authorities having jurisdiction.

.5 Use identification nameplate or identification label to identify information required by CSA C22.1 for marking of direct-current photovoltaic power sources. Locate at each DC disconnect means requiring marking.

.6 Use identification nameplate or identification label to identify interactive system point of interconnection at disconnecting means as power source and with rated AC output current and nominal operating AC voltage.

.7 Where inverter output connection is located in panelboard on opposite (load) end from input feeder location or main circuit location in order to meet requirements of CSA C22.1, use identification nameplate or identification label to identify overcurrent device with word message "Warning; Inverter output connection; Do not relocate this overcurrent device".

.8 Use warning labels to identify electrical hazards for photovoltaic system disconnecting means. Include word message "Warning -

Electric Shock Hazard; Terminals on the line and load sides may be energized in the open position" or approved equivalent.

.9 Use warning labels, identification nameplates, or identification labels to identify electrical hazards for photovoltaic systems equipped with DC ground-fault protection in accordance with CSA C22.1. Include word message "Warning - Electric Shock Hazard; If a ground fault is indicated, normally grounded conductors may be ungrounded and energized".

.10 Use wire and cable markers to identify photovoltaic system source, output, and inverter circuit conductors at points of termination, connection, and splices.

.11 Use voltage markers, identification labels, stenciled text, or suitable permanent marking approved by authority having jurisdiction to identify exposed raceways, cable trays, pull boxes, junction boxes, and conduit bodies with text "Warning: Photovoltaic Power Source" at maximum intervals of 3 m in accordance with CSA C22.1.

3.4 Site quality control

.1 See Section 01 45 00 – Quality Control for additional requirements.

.2 See article "SYSTEM STARTUP" below for additional requirements related to testing and inspection.

.3 Provide services of manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's detailed testing procedures and site reports with submittals.

.4 Inspection and testing to include, at minimum:

.1 Inspect each system component for damage and defects.

.2 Verify that equipment enclosures, boxes, and associated connections installed outdoors are weatherproof.

.3 Verify proper wiring connections have been made and check for conductor continuity. Verify proper polarity.

.4 Verify tightness of mechanical and electrical connections are according to manufacturer's recommended torque settings.

.5 Perform insulation resistance tests.

.1 Disconnect surge protective devices (SPDs) prior to performing high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.

.6 Measure and record ambient conditions, including date and time, ambient temperature, cell temperature, solar irradiance in module plane, and wind speed.

.7 Measure and record open circuit voltage of each string.

.8 Measure and record voltages at inverter AC and DC inputs.

.9 Measure and record operating current for each string, sub-array, and array.

.10 Measure and record AC output power.

.11 Perform inverter functional test.

.1 Grid-Tied Inverters: Include simulation of loss of utility power and subsequent power restoration.

.12 Verify proper operation of monitoring system.

.5 Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.

.6 Diagnostic Period: After successful completion of inspections and tests, operate system in normal mode for at least fourteen (14) days without system or equipment malfunctions.

.1 Record system operations and malfunctions.

.2 If malfunction occurs, start diagnostic period over after correction of malfunction.

.7 Submit detailed reports indicating inspection and testing results and corrective actions taken.

.8 Repair roof or adjacent roof-mounted items damaged as result of work of this section.

3.5 System startup

.1 Provide services of manufacturer's authorized representative to assist in performing system startup. Include manufacturer's detailed startup procedures with submittals.

.2 Obtain Owner's approval prior to performing system startup.

.3 Grid-Tied Systems: Obtain Supply Authority's approval prior to performing system startup.

.4 Prepare and start system in accordance with manufacturer's instructions.

3.6 Cleaning

.1 Clean modules using only methods recommended by manufacturer to avoid scratches and other damage. Clean exposed surfaces on other components to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.7 Commissioning

.1 See Section 01 91 00 – General Commissioning Requirements for commissioning requirements.

3.8 Closeout activities

.1 See Section 01 78 00 – Closeout Submittals for closeout submittals.

.2 See Section 01 79 00 – Demonstration and Training for additional requirements.

.3 Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.

.4 Training: Train Owner's personnel on operation, adjustment, and maintenance of photovoltaic system.

.1 Use operation and maintenance manual as training reference, supplemented with additional training materials as required.

.2 Provide minimum of four hours of training.

.3 Instructor: Manufacturer's authorized representative.

.4 Location: At project site.

3.9 Protection

.1 Protect installed products from subsequent construction operations.

3.10 Maintenance

.1 See Section 01 78 00 – Closeout Submittals for additional requirements relating to maintenance service.

.2 Provide to Owner, a proposal as alternate to base bid, a separate maintenance contract for service and maintenance of photovoltaic system for two years from date of Substantial Performance, to include work described below; Include complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with, a proposal as alternate to base bid, detailed schedule.

.3 Conduct site visit at least once every six months to perform inspection, testing, and preventive maintenance. Conduct tests similar to those made during original site quality control testing. Submit report to Owner comparing test results with those of original tests along with evaluations and recommendations.

.4 Provide trouble call-back service upon notification by Owner:

.1 Include allowance for call-back service during normal working hours at no extra cost to Owner.

.2 Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

1.2 Related requirements

.1 Section 26 05 00 – General Electrical Requirements

1.3 References

.1 CAN/CGSB-3.6-M90 - Diesel Fuel

.2 CAN4-S601-M84 - Standard for Shop Fabricated Steel Aboveground Horizontal Tanks for Flammable and Combustible Liquids

.3 NEMA MG1-87 - Motors and Generators

.4 Ontario Electrical Safety Code

.5 CSA C22.2 No. 5-M86 - Moulded Case Circuit Breakers

.6 CAN3-C13-M83 - Instrument Transformers

.7 CAN3-C17-M84 - Alternating - Current Electricity Metering

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 System description

.1 Provide a complete self-operating and autonomous standby emergency generator system consisting of diesel generator, controls, automatic transfer switches and accessories required to provide standby emergency power to the complete facility.

.2 System shall operate automatically to start on failure of utility power source, assume loads via automatic transfer switches, retransfer to utility power source when it is restored, continue to run in cool down period, and shutdown.

.3 System shall be capable of operating manually permitting it to be exercised with or without load.

.4 Standby rated emergency generator set to be provided with sub-base, double wall, fuel tank sized for fourty-eight (48) hour operation at full load.

.5 Generator, fuel tank, and exhaust silencer shall be contained within a skin tight, weatherproof, level-II sound attenuated enclosure and vibration pads.

.6 The generator and sub-base fuel tank will be complete with IBC seismic certification.

.7 BAS monitoring integration as outlined in 2.9 below.

1.6 Site conditions

.1 The system will be installed at a location with the following site conditions:

.1 Altitude above sea level: 370 m

.2 Minimum ambient temperature: -30 °C

.3 Maximum ambient temperature: 35 °C

.4 Minimum humidity: 0 %

.5 Maximum humidity: 100 %

.6 Voltage available for battery charger, engine heaters, fuel transfer pump etc., 120/208 VAC, 3 phase, 4 wire (100 Amp).

1.7 Submittals

.1 Submit with tender the following documentation:

.1 Outline dimension drawings (including weights) and manufacturer's descriptive literature of the following equipment:

.1 Structural steel mounting base

.2 Sound attenuating enclosure

.3 Diesel engine; make, model, performance curves, ratings

.4 Alternator; make, model, damage curve, ratings

.5 Governor; make, model, type

.6 Fuel supply system

.7 Exhaust system

.8 Cooling system

.9 Battery charger; make, model, type

.10 Battery; make, model, type, capacity

.11 Control panel

.12 P & IDs showing all systems in detail

.13 Description of operation for:

.1 Automatic starting, transfer, retransfer and shutdown

.2 Time from start signal to unit ready to accept full load

.3 Manual start and stop

.4 Automatic shutdown and alarm for each shutdown

.5 Remote emergency stop

.2 A list of tests which will be carried out on the equipment by manufacturer prior to shipping.

.3 A list of tests which will be carried out on the equipment by manufacturer at site after installation complete.

.4 Schedule indicating time to:

.1 Supply drawings for approval

.2 Commence manufacture

.3 Complete manufacture

.4 Factory tests

.5 Ship to site

.5 List of customers to whom diesel generating sets of similar specification and size have been supplied in the past and details of equipment supplied.

.6 Foundation loads.

.7 Noise data, dbA for entire spectrum @ 7 m from unit.

.8 Fuel consumption at full rated load (kg/hr).

.9 Details of maintenance departments, location of maintenance departments, twenty (24) hour response time.

.10 Submit list of recommended spare parts with price list.

.2 Submit, within four (4) weeks of contract award, in accordance with Section 26 05 00 – General Electrical Requirements, the following shop drawings, performance curves and documentation to the Consultant for review:

.1 Structural steel mounting base and vibration isolators.

.2 Engine: make, model and ratings with performance curves for:

.1 Horsepower versus engine speed

.2 Fuel consumption verses load (0 % to 110 %).

.3 Alternator: make, model and ratings with performance curves for:

.1 Time versus current damage curve.

.4 Control panel: layout, component descriptions.

.5 Voltage regulator: make, model and type.

.6 Automatic transfer switch: make, model and type.

.7 Battery: make, model, type and capacity.

.8 Battery charger: make, model and type.

.9 Fuel system components make, model and capacity for fuel tank

.10 Governor: make, model and type with performance values.

.11 Automatic engine room ventilation system and controls.

.12 Cooling air requirements in m^3/s and static head.

.13 P & IDs for all systems in complete detail.

.14 Exhaust silencer: make, model, type and ratings.

.15 Schematic and wiring diagrams of AC and DC systems, including all panel wiring, protection and interconnection (between panels) diagrams.

.16 Bill of material of main components.

.17 Main circuit breaker time verses current curve.

.18 Assembly drawing showing complete unit assembly.

.3 Submit at time of equipment delivery:

.1 Show on dimensioned drawings, generating set mounted on steel base, including vibration isolators, exhaust system, drip tray, radiator, engine, alternator, alternator terminal box and total weight.

.2 Dimensions and structural specifications for engine-generator foundations.

.3 Control and transfer switch panels. Include equipment layout drawings showing instruments, meters, relays and controls.

.4 Size and location of the following services:

.1 Fuel supply line

.2 Fuel return line

.3 Cooling water inlet

.4 Cooling water discharge

.5 Main power conduit(s)

.6 Control wiring conduit(s)

.7 Auxiliary power conduit(s)

.8 Exhaust

.5 Provide description of set operation including:

.1 Manual starting

.2 Automatic starting

.3 Load transfer

.4 Shutdown

.5 Pre-shutdown alarm functions

.6 Shutdown functions

.4 Submit the following a minimum of two (2) weeks prior to shipping:

.1 Maintenance manuals for equipment being supplied.

.2 Operation and installation instructions for equipment being supplied.

.5 Submit the following at the time of shipping:

.1 Certified test reports

.2 As-built drawings

1.8 Maintenance materials

.1 Provide the following maintenance materials to be shipped at the same time as the generating set:

.1 Air filter elements – quantity five (5) sets

.2 Lubricating oil filter elements – quantity five (5) sets

.3 Fuel oil filter elements – quantity five (5) sets

.4 Fuses - quantity two (2) sets

1.9 Quality assurance

.1 Ensure that components of the system are compatible with each other and are properly coordinated and aligned.

.2 Equipment supplied must be by a vendor who has been engaged in manufacture of this type of equipment specified herein on a continuous basis for a minimum period of five (5) years.

1.10 Delivery, storage & handling

.1 Do not ship equipment to site prior to completion of factory testing and acceptance of test results by Consultant.

.2 Equipment will be accepted at site by Owner if undamaged during shipping to site. After acceptance, Owner's contractor will unload the equipment and install it.

1.11 Project conditions

.1 Do not use generator set to provide power for construction or other purposes, except for site testing unless specifically approved in writing by Owner.

1.12 Warranty

.1 Warranty requirements shall be as indicated in the Contract Documents except for this equipment the duration of warranty period shall be two (2) years from Substantial Performance of Work.

1.13 Maintenance

.1 Provide maintenance services, parts, fluids, labour, travel, etc. as required during the warranty period at no additional cost to Owner.

.2 Provide a maintenance and repair log on site to record regular maintenance and system faults. Include a description of each service visit detailing maintenance and/or fault and work performed and parts replaced for each visit.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 General

.1 Use only new materials, each item entirely suitable for its application.

2.3 Acceptable manufacturers

.1 Kohler;

.2 Cummins;

.3 CAT; or

.4 Approved alternate.

2.4 Performance characteristics

.1 Provide generator set with the following characteristics when operated continuously under site conditions specified herein:

.1 Power Output: 450 kW, 562.5 kVA at 0.8 power factor, standby power rating.

.2 Voltage: 600/347 V, 3 phase, 4 wire, grounded wye.

.3 Voltage Regulation: Rated voltage 0.5 % for steady state conditions, 0.5 % for no load to full load and full load to no load with recovery to steady state conditions within one (1) second.

.4 Frequency: 60 Hz.

.5 Frequency Regulation:

.1 Steady State Performance: Rated frequency 0.25 %.

.2 Transient Frequency Performance: Less than 5 % variation for 50 % step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds. On application of a 100 % load step the generator set shall recover to stable frequency within ten (10) seconds.

.6 Wave Shape: Maximum 5 % deviation from a sine wave for any combination of operating conditions.

.7 Harmonic Distortion: Maximum 5 % total, maximum 3 % for any single harmonic.

.8 Telephone Interference Factor: Maximum 50.

.9 Start-up Time: Maximum ten (10) seconds from signal start for cold generator set to reach rated voltage and frequency and load transfer.

2.5 Structural steel mounting base

.1 Complete generating set mounted on structural steel base of sufficient strength and rigidity to protect assembly from torsional vibration, stress or strain during transportation, installation and under operating conditions on suitable level surface.

.2 Assembly fitted with vibration spring type isolators between the generator and sub-base fuel tank.

2.6 Engine

.1 Furnish engine of current manufacture with the following characteristics:

.1 Diesel, 4 cycle.

.2 Rated Speed: 1,800 rpm.

.3 Fuel: #2 diesel fuel to CAN/CGSB-3.6-M.

.4 Air Filter: Replaceable dry element type with a service indication device.

.5 Drip Pan: Removable, to collect dripping fluids from the engine.

.6 Statically and dynamically balanced and fully counterbalanced crankshaft.

.7 No harmful torsional or vibrations will occur with the engine-alternator combination furnished.

.8 Net engine power in accordance with ISO 3046.

.9 Derate engine as required for site conditions.

.10 EPA tier II emissions levels.

.2 Governor

.1 Adjustable isochronous, with speed sensing.

.2 The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions.

.3 The control system shall actively control the fuel rate as appropriate to the state of the engine generator. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed, and operating in various isochronous states.

.3 Cooling System

.1 Liquid Cooled: Thermostatically controlled, heavy duty industrial radiator mounted on generating set base with engine driven pusher type fan to direct air through radiator from engine side.

.2 With ethylene glycol anti-freeze non-sludging above (-46) °C.

.3 To maintain manufacturer's recommended engine temperature range from no load to 100 % of rated continuous load at the site conditions specified.

.4 Engine Coolant Heater: Thermostatically controlled coolant heater(s) connected to separate 120/208 V distribution panel to maintain engine at a suitable temperature for reliable starting at the site conditions indicated.

.4 Fuel System

.1 Fuel System: Direct injection, mechanical fuel transfer pump with hand primer, fuel filters, fuel solenoid value energized when engine running.

.2 Number 2 diesel fuel to CAN/CGSB-3.6-M.

.3 Fuel Filter: Replaceable element fuel filter(s) with valves to permit replacing the elements with the engine running.

.4 Install and plumb fuel water separator filter package

.5 Fuel Tank

.1 Fuel storage tank shall be double wall sub-base, mounted within generator enclosure on concrete pad with fill and vent lines routed to exterior of enclosure and fitted with weather heads.

.2 Fuel storage tank shall be ULC S601 listed. Tank shall be of sufficient capacity for twenty (24) hours continuous operation at full load.

.3 Fuel level gauge and vent alarm for fuel tank.

.4 Fuel tank float switches with discrete alarm contacts for:

.1 Low level alarm

.2 High level alarm

.5 External fuel vent and fill provisions in accordance with TSSA requirements.

.6 Flexible connections for fuel supply and return lines.

.7 Fuel for testing shall be provided by Contractor. Tank shall be filled following testing and acceptance.

.6 Exhaust System

.1 Heavy duty, super critical type (or better, as required), horizontally mounted exhaust silencer with condensate drain, plug and flanged couplings.

.2 Heavy duty flexible connection with flanged couplings to connect the exhaust manifold of the engine to the muffler.

.3 Fittings and accessories as required.

.4 Expansion Fitting(s): Stainless steel, corrugated, of suitable length, to absorb both vertical and horizontal expansion.

.5 Provide flanged connections to ANSI 150 lb dimensions.

.7 Lubrication System

.1 Pump: Positive displacement, engine driven.

.2 System: Full pressure with a spring loaded "bypass" valve to automatically maintain lubricating oil circulation if the filters become clogged.

.3 Lubricating oil cooler.

.4 Engine sump drain with valve and cap.

.5 Sump oil level dip stick.

.8 Starting System

.1 Positive shift, gear engaging dual starter, minimum 24 Vdc.

.2 Cranking limiter to provide three (3) cranking periods of ten (10) seconds duration, each separated by fifteen (15) seconds rest.

.3 Battery: Industrial type, lead acid storage battery suitable for engine cranking with sufficient capacity to crank engine for one (1) min at 0 °C without using more than 25 % of ampere hour capacity.

.4 Battery Manufacturers:

.1 Interstate;

.2 Alcad;

.3 C & D;

.4 Exide; or

.5 Approved alternate.

.5 Battery Charger: Constant voltage, solid state, two stage from trickle charge at standby to boost charge after use. Regulation: 1 % output for 10 % input variation. (Automatic boost for six (6) hours every thirty (30) days). Equipped with dc voltmeter, dc ammeter, on-off switch and power failure alarm.

.6 Battery Support: Steel battery support rack with a finish resistant to corrosion from battery electrolytic. Locate battery at side of engine.

.7 Cable: Cables from battery to starter motor(s) sized for a maximum 5 % voltage drop.

.8 Maintenance Tools: Maintenance tools including as a minimum:

.1 Hydrometer (lead acid only)

.2 Splash goggles

.3 Gloves

.4 Apron

.5 Insulated tools

.6 Battery maintenance instructions

.7 Cabinet for wall mounting to contain the above (cabinet to be located in main electrical room).

.9 Engine mounted instrument panel shock mounted engine instrument panel with:

.1 Lubricating oil pressure gauge. (kPa).

.2 Lubricating oil temperature gauge. (°C).

.3 Coolant temperature gauge at radiator (heat exchanger) inlet (°C).

.4 Coolant temperature gauge at radiator (heat exchanger) outlet (°C).

.5 Cooling water temperature gauge at inlet to heat exchanger (°C).

.6 Coolant level gauge.

.7 Tachometer.

.8 Non-resettable elapsed time meter (hours).

.9 Emergency shutdown for the following:

.1 Engine low lubricating oil pressure

.2 Engine high coolant temperature

.3 Engine low coolant level

.4 Engine overspeed

.5 Engine overcrank

.6 Engine emergency stop pushbutton.

.10 Alarm indicating lights for the following:

.1 Low day tank fuel level

.2 Low battery voltage

.3 Low coolant level pre-shutdown alarm

.4 Low lubricating oil pressure pre-shutdown alarm

.5 High coolant temperature pre-shutdown alarm

.6 Battery charger failure

.7 Alternator high temperature.

.11 Remote Indication: Provide one (1) common dry contact, for alarms specified, wired to terminal blocks in the control panel.

2.7 Alternator

.1 Alternator: to ANSI/NEMA MG1.

.2 Rating: 600 VAC, 3 phase, 4-wire, 450kW, 60 Hz, at 0.8 PF. Refer to sizing criteria in Section 2.11 below.

.3 Motor Starting Capacity: 1749 SkVA (90 % sustained voltage)

.4 Accessories

.1 Guards to protect personnel from hot and moving parts.

.2 Drip tray.

.5 Type: Synchronous with revolving field full Amortisseur windings.

.6 Enclosure: Drip proof.

.7 Cooling: Direct drive centrifugal fan.

.8 Single bearing, dynamically balanced rotor permanently aligned to engine by direct semiflexible steel disc type coupling.

.9 Two bearing dynamically balanced rotor connected to engine by flexible coupling.

.10 Exciter: Rotating, brushless, silicon type, singe protected rectifiers capable of sustaining 300 % of rated current for ten (10) seconds without damage.

.11 EEMAC class H insulation on rotor and stator with maximum 125 °C temperature rise at rated output at an ambient temperature of 40 °C.

.12 Space heater to prevent condensation with control devices and wiring.

.13 Voltage Regulator: Solid state, silicon controlled rectifiers with phase controlled sensing circuit, cross current compensation for parallel operation to provide:

.1 Transient Voltage Performance: Not more than 20 % variation for 50 % step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds. On application of a 100 % load step the generator set shall recover to stable voltage within ten (10) seconds.

.2 Steady State Voltage Regulation: 0.5 % of rated voltage at any load from no load to full load.

.3 Transient recovery to steady state operation in one (1) second.

.4 Provide field forcing to maintain the field for sufficient duration to permit main circuit breaker to trip during fault conditions. Alternator shall sustain 300 % rated current for ten (10) seconds to allow sequential tripping of protective devices.

.5 Adjustment range 10 %.

.6 Voltage range adjustment capability motor driven without local and remote control.

.14 Generator Overcurrent and Fault Protection:

.1 The generator set shall be provided with a UL Listed/CSA Certified protective device that is coordinated with the alternator to prevent damage to the generator set on any possible overload or overcurrent condition external to the machine.

.2 The protective device shall be listed as a utility grade protective device under UL category NRGU. The control system shall be subject to UL follow-up service at the manufacturing location to verify that the protective system is fully operational as manufactured.

.3 Current Rating: rated not less than the peak generator nameplate rating.

.4 With shunt trip, auxiliary alarm contacts and make/break position contacts.

.5 The load bank breaker shall be wired for activation of the trip in case of loosing Hydro power during load bank testing upon receiving the remote start signal from any of the Automatic Transfer Switches at site to dump the load bank testing and feed the building load.

.6 The main line circuit breaker shall be c/w auxiliary contact to monitor status of the CB and annunciate a trouble signal when CB is open.

.7 Test Circuit Breaker: Provide a second alternator output circuit breaker for connection of portable load bank.

.15 Method of grounding:

.1 At generator: Generator frame to be bonded to service ground. Neutral to be floating, not bonded to generator frame (in accordance with ESA Bulletin 10-10-8).

.2 At automatic transfer switch: Solid neutral at automatic transfer switch(es) is to be bonded to service ground (in accordance with ESA Bulletin 10-10-8).

2.8 Control panel

.1 Totally enclosed, EEMAC 12 control panel mounted on genset with formed panel door and lockable handle with 2 keys to CAN3-C13-M and panel to be supplied complete with:

.1 Switchboard instruments and meters to CAN3-C13-M and CAN3-C17-M

.2 Controls

.3 Program selector switch

.2 Digital Metering

.1 Provide a digital metering unit, controlled by a microprocessor, to provide the RMS values for the following metering functions:

.1 Voltage for each phase

.2 Current for each phase

.3 kVA

.4 kVAR

.5 kW

.6 Power factor

.7 Frequency (Hertz)

.8 Accumulated MWh

.9 kW demand

.2 Provide storage, in non-volatile memory, of the following parameters:

.1 Maximum and minimum values of voltage (per phase)

.2 Maximum and minimum values of power factor

.3 Maximum value of current (per phase)

.4 Maximum value of kVA

.5 Maximum value of kVAR

.6 Maximum value of kW

.7 Maximum value of kW demand

.3 Provide three (3) set points, each with a dry contact, field programmable for user selectable kW demand.

.4 Provide rear mounted RS-232C port to permit communication with a remote computer.

.5 Manufacturers: Power Measurement Ltd. - Model "3710" or approved alternate.

.3 Controls

.1 Mode selector switch labelled Auto-Off-Manual-Test. Operation as described in System Description.

.2 Engine and control panel mounted, deliberate action, emergency stop buttons plus provision for remote emergency stop button.

.3 Voltage control device to be mounted on the inside of control panel and to be screwdriver-adjust type with locking nut.

.4 Close differential voltage sensing relay for normal source, 1 per phase, pickup voltage adjustable from 85 % to 100 % of nominal, dropout adjustable from 75 % to 98 % of pickup setting.

.5 Voltage sensing relay, one (1) per phase pickup adjustable from 85 % to 100 % of nominal.

.6 Frequency sensing relay for emergency source, pickup adjustable from 90 % to 100 % of nominal retransfer to normal source delay.

.7 Time delay, from zero (0) to thirty (30) minutes.

.8 Time delay relay to delay engine starting to override momentary power outages or dips, adjustable from one (1) second to six (6) seconds.

.9 Time delay relay for engine cool-down to permit standby set to run unloaded after retransfer to normal source, adjustable from zero (0) to thirty (30) minutes.

.4 Provide automatic shut-down, local horn with silence pushbutton and alarm annunciator with acknowledge and reset pushbuttons for functions listed below. The system shall be equipped with common alarm contacts

for remote annunciation. All alarm shall be manually reset, unless otherwise indicated, momentarily energized, with a set of NC/NO contacts wired to terminal blocks for connection to the annunciator.

.1 Engine overcrank.

.2 Engine overspeed.

.3 Engine high coolant temperature.

.4 Engine low lubricating oil pressure.

.5 Low coolant temperature.

.6 Low fuel level.

.7 Low coolant level.

.8 Manual local/remote emergency stop.

.9 Electrical fault.

.10 Ground fault.

.11 High alternator winding temperature.

.12 All generator protection equipment.

.13 Low battery voltage, or no battery charge continuously monitored even when engine not running. - Auto reset alarm.

2.9 BAS monitoring integration

.1 Coordinate with BAS system provider for interconnecting wiring between generator and BAS system for the following signals as a minimum:

.1 Generator Run

.2 Generator Trouble

.3 General Alarm

.4 Fuel Tank Signals:

.1 High tank alarm.

.2 High high tank alarm.

.3 Low tank alarm.

.4 Integrated Fuel Measurement system.

.5 Fuel Leak alarm

.6 Diesel Generator battery alarm

.7 Over fill protections

2.10 Fire alarm monitoring integration

.1 Coordinate with fire alarm system provider for interconnecting wiring between generator and fire alarm system for the following signals as a minimum:

.1 Generator Trouble

2.11 Outdoor enclosure (sound attenuated)

.1 The generator set shall be provided within an outdoor enclosure. The package shall comply with the requirements of the Ontario Electrical Safety Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and double wall, sub-base fuel tank shall be designed to be lifted into place using spreader bars. The enclosure shall be sized to encompass the full overall dimensions of the sub-base fuel tank.

.2 The enclosure shall provide weather protection and include an internally mounted critical grade exhaust silencer and sound insulating panels which reduce the sound level of the set to a level of 75 dBA or less measured 7m from the enclosure.

.3 Enclosure shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100 °F. Fixed intake/exhaust louvers with motorized dampers shall be wired to motor close and spring open

.4 The enclosure shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable, and include retainers to hold the door open during service. Enclosure roof shall be designed to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.

.5 All sheet metal shall be primed for corrosion protection and finish painted custom colour (to be confirmed at shop drawing review) using a powder coat paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted.

.6 Enclosure material shall be either steel or aluminum. Steel enclosure shall be constructed of minimum 12 gauge steel for framework and 14 gauge steel for panels. Aluminum enclosure shall be wind rated for 150 mph conditions. All enclosure hardware and hinges shall be stainless steel.

.7 A factory-mounted exhaust silencer shall be installed inside the enclosure, and insulated as necessary to allow generator set to operate at rated load in the maximum specified ambient temperature. Exhaust connections to the generator set shall be through seamless flexible connections.

.8 Electrical Provisions:

.1 Electrical provisions shall comply with the requirements of the Ontario Electrical Safety Code, Electrical Safety Authority.

.2 Provide an internally mounted and wired electrical distribution panel to serve the engine generator and enclosure including:

.1 100 amp distribution panelboard connected to a 3 phase 120/208 VAC utility service by the installing Contractor.

.2 Two duplex GFI receptacles, one inside the enclosure, and a weatherproof receptacle on the outside of the enclosure.

.3 Factory wired normal AC service from the panelboard to the engine coolant heater, alternator heater, and battery charger.

.4 Interior Lights with local Switch: Two three-way switches controlling three AC lamps mounted in vapor tight and gasketed fixtures.

.5 Interior Emergency Lights: Self-contained, battery operated emergency lighting unit(s) to illuminate the interior service areas in the event of a power failure and failure of the generator.

.3 External Electrical Connections: All power and control interconnections shall be made within the perimeter of the enclosure.

.9 The enclosure shall include the following maintenance provisions:

.1 Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves

.2 External radiator fill provision.

.3 Provide motorized louvers to minimize air flow through the enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.

2.12 Automatic transfer switch

.1 Automatic transfer switch to be included as part of main switchgear as per Specification 26 24 02 – Service Entrance Switchboard.

2.13 Finishes

.1 The engine and alternator shall be standard finished heat resistant.

.2 Colour of generator enclosure shall be selected to match existing building exterior. Colour chip to be submitted with shop drawings for review/approval by Consultant and Owner.

.3 Supply 1 L of touch-up enamel for enclosure.

2.14 Fabrication

.1 Shop assemble generating unit including:

.1 Base

.2 Engine (and radiator)

.3 Alternator

.4 Control panel

.5 Battery and charger

.6 Generator enclosure

.7 Exhaust and silencer

.2 Accessories

.1 Furnish the following accessories as a minimum:

.1 One set - special tools required for service and maintenance

.2 One litre touch-up paint for touching up engine, generator and enclosure.

2.15 Generator sizing criteria

.1 The generator shall be selected to accommodate all loads that will be connected as shown in the drawings. Percent rated capacity of load on generator shall not exceed 80 %.

.2 A summary of these loads is provided below.

.3 Generator Load Characteristics:

.1 First step load on generator will be lighting, receptacle, miscellaneous house panel loads, HP-1 and other miscellaneous HVAC equipment.

.2 Second step load on generator will be HP-2. HP-2 will not be started at the same time as HP-1. HP-2 will be started if room thermostats or pipe temperature sensors are not satisfied by HP-1.

.4 Loads to be supported by standby generator:

Load Step	Running		Inrush	Inrush on Genset	Delay	Load Type
	kW	kVA	kVA	kVA		
1	247	274	332	567	No	Lighting, Receptacles, Misc House Panel Loads, HP-1, EV, Misc. HVAC
2	24	27	92	229	Yes	HP-2
Total	272	332				

.5 Voltage drop shall not exceed 20 % and frequency dip must not exceed 7 %.

3 Execution

3.1 Factory testing

.1 After manufacturing completion of equipment, factory test generator set including engine, alternator, control panels, and accessories. Provide type test certificates by a recognized testing authority proving compliance of equipment with this specification.

.2 Regulation Test: Connect engine block heaters to maintain normal temperature during standby. Install continuous strip chart recorders to record frequency and voltage variations during load switching procedures, with chart speed of 1.3 mm/s. Each load change delayed until steady state conditions exist. Perform rated load tests at the rated PF. Switching rated PF load increments to include:

.1 No load to full load to no load.

.2 No load to 70 % load to no load.

.3 No load to 20 % load to no load.

.4 20 % load to 40 % load to no load.

.5 40 % load to 60 % load to no load.

.6 60 % load to 80 % load to no load.

3.2 Installation

.1 Locate generating unit and install as indicated.

.2 Install control panel, transfer switch and power distribution equipment as indicated.

.3 Complete wiring and interconnections as indicated.

.4 Start generating set and test to ensure correct performance of components.

3.3 Site testing

.1 Tests shall be in accordance with the requirements of NFPA 110 for standby power systems, performed by manufacturer's qualified representatives and witnessed by Consultant and the Owner's operating staff.

.2 Submit three (3) copies of site test report to Consultant with Operating and Maintenance Manuals.

.3 Notify Consultant ten (10) working days in advance of test date.

.4 Demonstrate the proper operation of the automatic transfer switches.

3.4 Demonstration

.1 Demonstrate proper operation and routine maintenance procedures of diesel generator set to Owner. Allow for two demonstration periods of two (2) hours at separately scheduled dates.

.2 Demonstration shall include the following:

.1 Engine will not start in "OFF" position.

.2 Engine will start in "test" position and transfer takes place. Switch to "Auto" position to stop engine.

.3 "Auto" position - Automatic starting of set and automatic transfer of load on failure of normal power. Automatic shut down of engine on resumption of normal power.

.4 "Manual" position - Engine starts but unit will not transfer unless normal power supply fails. Return switch to "Auto" position to stop engine.

.5 Program selector switch set at "AUTO".

.1 On "normal power" failure, after two (2) seconds, adjustable time delay, engine starts. When frequency and voltage reach rated values, the load is transferred on to generator.

.2 On restoration of "normal power" and after twenty (20) seconds, adjustable time delay, during which frequency and voltage is maintained at rated values, system is automatically synchronized, i.e. Hydro power and generator power, and the generator load is transferred back to normal power. The engine will shut down after a predetermined time delay.

.6 Program selector switch set at "TEST".

.1 Normal power failure simulated. Engine starts and automatic transfer takes place. Return switch to "Auto" to gradually unload generator and stop engine after cooling down period.

.7 Program selector switch set at "MANUAL".

.1 Start button controls engine but automatic transfer of load prevented unless normal power supply fails.

.8 Program selector switch set at "OFF".

.1 Engine will not start.

.2 Switch lockable in this position.

.9 That battery charger operates and that battery charger changes to high rate charge after cranking.

.10 Demonstrate low oil pressure and high engine temperature shut downs by removing sensors and installing in test equipment to produce excessive oil pressure and high temperature at devices without subjecting engine to these excesses.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

1.2 Related requirements

.1 Section 26 05 00 – General Electrical Requirements

.2 Section 26 24 16.01 – Panelboards and Circuit Breakers

1.3 References

.1 UL 1449, Second Edition - Standard for Surge Protective Devices.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Scope

.1 Provide transient voltage surge suppression devices for service entrance switchboard MEDP, distribution panels and panelboards as detailed on drawings.

1.6 Shop drawings

.1 Submit shop drawings in accordance with Section 26 05 00 – General Electrical Requirements and the requirements of Division 1.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 All TVSS devices shall be of one manufacturer and be of same manufacture as panelboard and panelboard components. Acceptable Manufacturers: Eaton, Schneider Electric, Siemens, or approved alternate.

.2 All material shall be specification grade, new and carry CSA approval

2.3 General

.1 Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.

.2 Custom Operating Voltages – Refer to drawings for IEC rated panel voltages.

.3 Maximum Continuous Operating Voltage (MCOV) – The MCOV shall be greater than 115 % of the nominal system operating voltage.

.4 The suppression system shall incorporate a hybrid designed Metal-Oxide Varistors (MOV) surge suppressor for the service entrance and other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cell, air gaps or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.

.5 Protection Modes – For a wye configured system, the device must have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G). For a delta-configured system, the device must have suppression elements between line to line (L-L) and line to ground (L-G).

.6 The maximum UL 1449 SVR for the device must not exceed the following:

.1	208Y/120	L-N, L-G, N-G: 400 V	L-L: 800 V
.2	600Y/347	L-N, L-G, N-G: 1200 V	L-L: 1800 V

.7 The let through voltage based on IEEE C62.41 and C62.45 recommended procedures for Category C3 surges (20 kV, 10 kA) shall be less than:

.1 208Y/120 L-N: 560 V

.2 600Y/347 L-N: 1840 V

.8 The let through voltage based on IEEE C62.41 and C62.45 recommended procedures for Category B3 ring wave (6 kV, 500 A) shall be less than:

.1 208Y/120 L-N: 160 V

.2 600Y/347 L-N: 168 V

.9 The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV.

.10 Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 50 dB at 100 kHz using the MIL-STD-220A insertion loss test method. Products not able to demonstrate noise attenuation of 50 dB @ 100 kHz shall be rejected.

.11 No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings.

.12 Each TVSS shall provide integral monitoring options:

.1 Each unit shall provide a green / red solid state indicator light on each phase. The absence of a green light and the presence of a red light, shall indicate which phase(s) have been damaged.

.2 Remote Status Monitor – The TVSS device must include form C dry contacts (one NO and one NC) for remote annunciation of unit status. The remote alarm shall change state if any of the three phases detect a fault condition.

.3 Audible Alarm – The TVSS shall provide an audible alarm with a reset pushbutton that will be activated under any fault condition.

.4 Event Counter – The TVSS shall be equipped with an LCD display system designed to indicate to the user how many surges, sags, swells and outages have occurred at the location. The event counter triggers each time under each respective categories after

significant event occurs. A reset pushbutton shall also be standard allowing all counters to be zeroed.

.5 Push to Test – The TVSS shall be equipped with push-to-test feature is designed to provide users with real time testing of the suppressor's monitoring and diagnostic system. By depressing the test button, the diagnostic system initiates a self test procedure. If the system is fully operational, the self test will activate all indicator lights.

.6 Voltage Monitoring – The TVSS shall display true Root Mean Square (RMS) on three L-N voltage protection mode on Wye configuration and three L-L voltage on delta configuration.

.13 Overcurrent Protection Fusing: In order to isolate the TVSS under any fault condition, the manufacturer shall provide:

.1 Individual Fusing: MOV's shall be individually fused via Copper Fuse Trace. The Copper Fuse shall allow protection during high surge (kA) events.

.2 Thermal Protection: MOV's shall be equipped with Thermal Fuse Spring (TFS) Technology which allows disconnection of the suppression component at the overheated stage common during temporary over voltage condition. For small fault currents between 100 mA to 30 Amp, or if the occurrence is over a longer period of time, the TFS will disconnect first. Manufacturers that utilize fuse trace only shall not be approved since there is no fault current protection between 100 mA to 30 A.

.3 All overcurrent protection components shall be tested in compliance with UL 1449-Limited Current Test and AIC rating test.

.14 Minimum Repetitive Surge Current Capability as per ANSI/IEEE C62.41 and ANSI/IEEE C62.45 – 1992 suppression filter system must be repetitive surge tested in every mode utilizing a 1.2 x 50 µsec, 20 kV open circuit voltage. 8 x 20 µsec, 10kA short circuit current Category C3 bi-wave at one minute intervals without suffering either performance degradation or more than 10 % deviation of clamping voltage at a specified surge current.

.1 Service Entrance: 12000 impulse per mode.

.2 Distribution Panelboard: 10000 impulse per mode.

.3 Branch Location Panelboard: 9000 impulse per mode.

2.4 Application

.1 The TVSS applications covered under this section include distribution and branch panel locations and switchboard assemblies. The branch panel located TVSS shall be tested and demonstrate to be suitable for ANSI/IEEE C62.41 Category C1 environments.

.2 Surge Current Capacity - The minimum total surge current 8 x 20 microsecond waveform that the device is capable of withstanding shall be as shown in the following table:

Minimum total surge current and withstand Capability with compliance to ANSI/IEEE C62.41 AND NEMA LS1			
Application	Per Phase	Per Mode	Surge Withstand Capabilities ANSI/IEEE C3 Wave (10kA)
Service Entrance Locations (Switchboards, Switchgear, Main Entrance)	250kA	125kA	12000
High Exposure Locations (Distribution Panelboards)	160kA	80kA	10000
Branch Locations (Panelboards)	120kA	60kA	9000

.3 Lighting and Distribution Panelboard Requirements

.1 The TVSS application covered under this section includes lighting and distribution panelboards. The TVSS units shall be tested to demonstrate suitability for ANSI/IEEE C62.41 Category C1 environments.

.2 The panelboard shall be capable of re-energizing upon removal of the TVSS.

.3 A direct bus bar connection shall be used to mount the TVSS component to the panelboard bus bar to reduce the impedance of the shunt path.

.4 The TVSS panelboard shall be constructed using a direct bus bar connection (cable connection between bus bar and TVSS device is not acceptable). TVSS units that use a cable connection do not meet the intent of this specification.

.5 The TVSS shall be included and mounted within the panelboard by the manufacturer of the panelboard.

.6 The TVSS shall be of the same manufacturer as the panelboard.

.7 The complete panelboard including the TVSS shall be UL67 listed.

3 Execution

3.1 Switchboard TVSS devices

.1 Suppression devices shall be installed in the switchboard by the switchboard manufacturer.

.2 Locate suppression devices on the load side of the main disconnect device, as close as possible to the phase bus and ground/neutral bus.

.3 Provide overcurrent/disconnecting means as required. This disconnect shall be directly integrated to the suppressor and switchboard bus using bolted bus bar connections.

.4 The suppressor and disconnect shall be connected to the switchboard using a direct bus bar connection (no cable connection between bus bar and TVSS device).

.5 All monitoring diagnostics features such as indicator lights, trouble alarms and surge counter, shall be mounted on the front of the switchboard.

3.2 Panelboard TVSS devices

.1 Panel suppressors shall be installed within the panelboards at the manufacturer’s factory.

.2 A direct bus bar connection shall be used to mount the TVSS component to the panelboard bus bar to reduce the impedance of the shunt path.

End of section

1 General

1.1 Section includes

.1 Provision of lighting fixtures (luminaires) complete with lamps, all accessories as detailed herein and in the lighting fixture schedule (on drawings).

1.2 Related requirements

.1 Contractor shall be responsible for co-ordinating this section with all related sections.

1.3 References

.1 C22.2 No. 250.0 – Luminaires.

.2 C22.2 No. 9.0 - General Requirements for Luminaires.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Shop drawings

.1 Submit in accordance with the General Conditions and Section 01 33 00 – Submittal Procedures.

1.6 Warranty

.1 All LED luminaires shall be supplied with a minimum five year warranty starting from date of Substantial Performance.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 All material shall be specification grade, where applicable, new and carry CSA approval or special certification as per Electrical Safety Authority requirements.

.2 Similar devices and items shall be from one manufacturer throughout the project.

.3 Refer to Lighting Fixture Schedule on drawings for details of fixtures to be supplied. Where alternate fixtures are proposed, provide submission prior to tender close in accordance with Section 26 05 00 – General Electrical Requirements.

.4 Internal fixture wire:

.1 Interior: #16 minimum Types TFF or TEW rated for 150 °C @ 600 volt or 1000 volt.

.2 Exterior (Poles): #12 minimum Type RW90 XLPE to connect external power supply.

.5 Connectors: Insulated solderless connector (crimping type).

2.3 LED luminaires

.1 Remote phosphor technology providing increased efficiency and color consistency. Color shift shall not exceed +/- 100K over life of lamp.

.2 Rated Life: Based on IESNA LM-80-2008.
L70 of ≥ 50,000 hours at 70 % lumen maintenance at 25 °C outdoor and 55 °C for indoor, and supported by IES LM-80 and IES TM-21 calculations

.3 LED light engine/module, driver, and all accessory components to be field replaceable.

.4 Fixture-integrated passive heat sinking.

.5 IES file based on IES LM-79.

.6 Exterior fixtures to be complete with glare control and surge suppression.

.7 Provide IP rating for exterior fixtures and for fixtures located within interior wash down areas. Overall fixture to be weatherproof.

.8 Photo cells (where required) to be compatible with LED Driver.

.9 LED retrofit luminaire conversion kits are not acceptable.

.10 LED drivers shall provide dimming capability where required; refer to fixture schedule on drawings for fixtures to be dimmed.

2.4 Fixture construction

.1 All interior fixtures shall comply with CSA Standard C22.2 No.9, latest edition, complete with accessories and components, complying with relevant CSA standards applicable to accessory or component.

.2 Where fixture lens is specified, it shall be 100 % virgin acrylic minimum 3.2 mm (.125 in.) thick.

.3 Fixture colour shall be as detailed in schedule. Baked enamel unless noted otherwise, which shall resist chipping, corrosion and discolouration. Before finishing all metal shall be chemically degreased and neutralized. Where custom fixture colours are required, colour shall be confirmed via shop drawing submission.

.4 All fixtures shall be CSA approved and/or carry certification by a certifying organization recognized by the Electrical Safety Authority.

2.5 Lighting poles

.1 Manufacturers:

.1 Valmont Industries Inc.;

.2 Dynapole, a division of Dynametal Industries Ltd.; or

.3 Approved alternate.

.2 Pole Height:

.1 3,800 mm, complete with pole base bolt circle in accordance with pole manufacturer’s recommendation.

.2 9,100 mm, complete with pole base bolt circle in accordance with pole manufacturer’s recommendation.

.3 Steel Poles:

.1 Designed for underground wiring. Tapered, minimum 127 mm square, heavy duty, and minimum 3 mm thick hot-dip galvanized steel, polyester powder-coated, and painted in accordance with pole schedule. Actual geometry, length, and size in accordance with Contract Drawings.

.2 Box type access handhole, with re-enforcing frame and weatherproof cover for wiring connections. Locate centre of handhole 400 mm to 450 mm above pole bottom and to suit Site conditions.

.3 Secure fish wire (yellow colour, waterproof, 6 mm dia. polypropylene rope) inside pole to facilitate cable installation.

.4 Grounding lugs suitable for maximum of 16 mm² (No. 6 AWG) ground wire inside handhole.

.5 Steel anchor base plate, with four slotted openings for 4 galvanized steel anchor bolts, minimum 19 mm dia. Include anchor hole templates.

.6 Rust proof and tamper resistant full base cover. Approved material ABS plastic with UV inhibitor.

.4 Aluminum Poles:

.1 Design for underground wiring. Straight, minimum 125 mm square, seamless tubes of aluminum alloy 6063, T6 heat tempered. Minimum 4.5 mm thick with semi-lustrous satin finish. Actual geometry, length, and size in accordance with Contract Drawings.

.2 Include box type access handhole, with reinforcing frame and weatherproof cover for wiring connections. Locate centre of handhole 400 mm to 450 mm above pole bottom and to suit Site conditions.

.3 Secure fish wire inside pole to facilitate cable installation.

.4 Grounding lugs suitable for maximum of 16 mm² (No. 6 AWG) ground wire inside handhole.

.5 Anchor base of cast aluminum alloy A356, T6 temper with poles. Fabricate plate with four slotted openings for 4 galvanized steel anchor bolts, minimum 19 mm dia. Include anchor hole templates.

.6 Rust proof and tamper resistant full base cover. Approved material ABS plastic with UV inhibitor.

2.6 Luminaire mounting arms and pole accessories

.1 Provide mounting arms for luminaire based on pole type, style, and number of luminaires in accordance with Contract Drawings.

.2 Attach arms to pole and luminaire house with no visible hardware or by welding.

.3 Where required, photocell and photocell receptacle shall be installed and secured to top of luminaire.

.4 Provide pole top cover as required.

3 Execution

3.1 Installation

.1 Co-ordinate fixture locations with other trades on site prior to rough in.

.2 Install fixtures complete with all mounting hardware and trims for a neat, finished appearance.

.3 Ensure that all fixtures installed in built-in enclosures can be serviced.

.4 Do not suspend light fixtures from ductwork, piping, mechanical equipment or their supports. Fixtures to be supported independently off ceiling system.

.5 Luminaires in service areas and mechanical or electrical rooms to be installed after mechanical and electrical equipment are in place. Luminaires to be located clear of obstructions.

.6 Do not daisy-chain light fixture wiring. Provide junction boxes and individual wiring to each light fixture.

.7 Luminaires in Vehicle Bay 131 shall be installed at 4500mm AFF. Coordinate with fan installer to ensure the lighting is installed below or at the same height as the fans to avoid “blinking” effect.

3.2 luminaire alignment

.1 Align luminaires mounted in continuous rows to form straight uninterrupted line.

.2 Align luminaires mounted individually parallel or perpendicular to building grid lines (unless indicated otherwise on drawings).

3.3 luminaire supports

.1 General:

.1 Support fixtures as shown on the drawings, level, plumb and true with the structure and other equipment, and in a horizontal or vertical position as intended.

.2 Wall or side bracket mounted fixture housings shall be rigidly installed and adjusted to give a neat flush fit to the surface on which it is mounted.

.3 All hangers, supports, fastenings or accessory fittings shall be protected against corrosion. Care shall be taken during the installation to assure that insulation and corrosion protection is not damaged.

.2 Supports:

.1 Support fixtures by mounting arrangements which will not cause the fixture frame, housing, sides or lens frame to be distorted, or prevent complete alignment of several fixtures in a row.

.2 Mounting methods for fixtures on or in suspended ceilings are to be as follows:

.1 Secure surface mounted equipment with twist clip fasteners to inverted 'T' bar ceilings and independently support clips using jack chain to structure above.

.2 Where cross member supports are required above the ceiling to provide support points, these are to be steel channels or angles.

.3 Toggle bolts of the snap-on or spring-in type are not to be used through drywall, tile or similar type ceilings.

.4 Lay-in or recessed luminaires (or luminaires mounted to the lower surface of suspended ceilings) shall be secured to the

building structure. Each fixture shall be secured at opposite ends by a minimum of No. 12 AWG (2.70 mm) galvanized soft annealed, mild steel wire (pencil rod) or fixture chain of adequate strength.

.3 Suspension Length:

.1 The suspension length for all ceiling-mounted, suspended types of lighting fixtures, as listed in the Fixture Schedule, shall be the overall length from the ceiling to the lowest point of the fixture body, reflector, or glassware in its hanging position.

.2 The length of the chain hangers of suspended fluorescent lighting fixtures shall be adjusted to hang all fixture bodies in the same room level and in the same horizontal plane, unless specifically required to be otherwise on the electrical drawings.

.4 Chain Hangers:

.1 Where site conditions require chain hangers in lieu of aircraft cable, fixtures to be specified to be chain hung, the chain used shall be No. 4 Tensile bright zinc coated with a strength of 181 kg. Attachments shall be made using No. 105 'S' hooks. Wires running down chain to fixture shall be run in flexible conduit and shall be attached to chain with cable clips.

3.4 Poles

.1 Erect poles true and plumb on foundations, using necessary shims, anchor bolts, lock washers, and nuts. Pack applicable grout and/or sealant under pole base to ensure full contact with foundation. Install drain hole through grouting.

.2 Install luminaires on poles/brackets and connect to pole wiring. Install lamps as indicated on Contract Drawings.

.3 Connect pole wiring to exterior lighting circuits in handhole at pole base. Ground in accordance with OESC and Contract Drawings.

.4 Use ILESSCO connectors to connect incoming Hot and Neutral conductors with fixture wires. Use of marretts or wire nuts not acceptable.

3.5 Wiring

.1 Refer to Section 26 05 05 – Basic Materials and Methods for acceptable wiring methods.

.2 Connect luminaires to lighting circuits as detailed on drawings.

.3 Refer to Section 26 09 24 – BAS Integrated Lighting Control Field Devices and drawings for lighting controls.

3.6 Cleaning

.1 Immediately prior to completion of project, provide a final cleaning of fixtures in accordance with Section 26 05 00 – Basic Materials and Methods and Division 1.

End of section

1 General

1.1 Section includes

.1 All conditions of the Contract apply to the work of this Section.

1.2 Related requirements

.1 Section 26 05 00 – General Electrical Requirements

1.3 References

.1 CSA C22.2 No.141-10 - Emergency Lighting Equipment.

.2 CAN/CSA C860-11 - Performance of Internally Lighted Exit Signs.

.3 OESC Section 46 - Emergency Power Supply, Unit Equipment, Exit Signs and Life Safety Systems.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Scope

.1 Provide a complete and operational emergency lighting and exit sign system capable of operating (upon loss of normal power) for a minimum of thirty (30) minutes under full load conditions.

1.6 Shop Drawings

.1 Submit shop drawings in accordance with Section 26 05 00 – General Electrical Requirements and the requirements of Division 1.

1.7 Warranty

.1 Emergency lighting equipment units shall be fully warranted to be free of defects in material and workmanship under normal use for a period of two (2) years, starting from date of Substantial Performance.

.2 Emergency lighting unit equipment batteries shall be warranted to be free of defects in material and workmanship under normal use for a period of two (2) years full and eight (8) years Pro Rata, starting from date of Substantial Performance.

.3 LED lamps used in Exit signs shall be warranted to be free of defects in material and workmanship under normal use for a period of ten (10) years.

.4 The full warranty period shall begin on the date of substantial completion of the project.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 All material shall be specification grade, where applicable, new and carry CSA approval or special inspection approval (in accordance with OESC).

.2 Similar devices and items shall be from one manufacturer throughout the project.

.3 Equipment detailed in this specification is based on Lumacell. Equipment supplied by the following manufacturers (equivalent to that specified) will also be acceptable: Emergi Lite, Luxnet, Hubbell, or approved alternate.

2.3 Emergency lighting

.1 Emergency lighting equipment shall be manufactured to CSA C22.2 No.141.

.2 Lumacell RGC Series or approved alternate.

.3 Supply voltage: 120 VAC.

.4 Output voltage: 12 VDC.

.5 Operating time: thirty (30) minutes (minimum).

.6 Battery: long life, sealed, maintenance free.

.7 Charger: solid state, multi-rate, voltage/current regulated, inverse temperature compensated, short circuit protected with regulated output of plus or minus 0.01 V for plus or minus 10 % input variations.

.8 Solid state transfer circuit.

.9 Low voltage disconnect: solid state, modular, operates at 80% battery output voltage.

.10 Signal lights: solid state, for 'AC Power ON' and 'High Charge'.

.11 Lamp heads: integral on unit, unless otherwise noted. Lamp type: LED style LD9, 5W, MR16, standard two head configuration unless otherwise noted.

.12 Remote Lamp Heads:

.1 Lumacell MQM-NX Series or approved alternate.

.13 Auxiliary equipment:

.1 Test switch.

.2 Cord and plug connection for AC.

2.4 Self powered exit signs – general use

.1 Exit signs to comply with CSA 22.2 No. 141-15 and C860 latest edition.

.2 For use in Open Office/Corridor areas: Lumacell LD Series or approved alternate.

.3 Housing: die-cast aluminum housing, black finish.

.4 Faceplate(s): selectable green directional pictogram

.5 Lamps: Long life, energy efficient light emitting diode (LED).

.6 Self powered option (supplied with internal battery for emergency power sized for 120 min. autonomous operation upon AC loss).

.7 Voltage and power:

.1 Dual Voltage AC: 120/347 Vac, max. 3.5 W.

2.5 Self-powered exit signs – work areas and vehicle bay

.1 Exit signs to comply with CSA 22.2 No. 141-15 and C860 latest edition.

.2 For use in Work/Vehicle Bay areas: Lumacell LA Series or approved alternate.

.3 Housing: one piece aluminum housing, black finish.

.4 Faceplate(s): selectable green directional pictogram

.5 Lamps: Long life, energy efficient light emitting diode (LED).

.6 Self powered option (supplied with internal battery for emergency power sized for 120 min. autonomous operation upon AC loss).

.7 Voltage and power:

.1 Universal Voltage AC: 120 to 347 Vac, max. 2.5 W.

2.6 Combination emergency lighting & exit sign

.1 Where combination emergency lighting & exit sign is to be provided, units shall be in accordance with above specifications.

.2 For utility rooms locations: Lumacell LAC series or approved alternate.

3 Execution

3.1 Emergency lighting

.1 Install all fixtures plumb and true. Adjust/aim remote lighting heads as required by the exit path.

.2 Mounting heights of battery pack and wall-mounted fixtures in open office and corridor areas shall be 2,280 mm (7 ft. 6 in.) to centre where height and space permits.

.3 Size all low voltage conductors so that the maximum voltage drop from the terminals of the battery pack to the connections to the last fixture on any circuit or branch circuit does not exceed 5 %.

.4 Mount the receptacle directly above battery unit on supply cord side.

.5 Conform to the Ontario Electrical Safety Code and ensure that new emergency battery units are connected to the local lighting circuit unless noted otherwise.

.6 Perform voltage measurements at points as requested by the Consultant to demonstrate the installation complies with this specification.

.7 On final inspection, in the presence of the Consultant, disconnect the battery units from the A.C. power supply for thirty (30) minutes to demonstrate their load carrying capacities.

3.2 Exit signs

.1 Install fixtures complete with all mounting hardware and trims for a neat, finished appearance.

.2 Install exit fixture wiring in a separate raceway system circuited to a separate circuit breaker in accordance with the requirements of the Ontario Electrical Safety Code. Provide lock-on device for circuit breaker handles, paint red and identify as “EXIT LIGHTING CIRCUIT”.

.3 Install exit fixture DC wiring in a separate raceway system. Connect to local emergency lighting battery unit as indicated on the drawings.

End of section

1 General

1.1 Section includes

.1 Labour, products, equipment and services necessary to complete the work of this Section including:

.1 The provision of cabling raceways and rough-in for telecom systems including fire rated cabling pathways where noted,

.2 The provision of telecom grounding for telecom systems,

.3 Miscellaneous equipment as detailed within the specifications and drawings.

.2 Section Does Not Include

.1 Horizontal data/telephone cabling, cable television cabling, backbone cabling, racks, patch panels, data switches, UPS equipment, related accessories including installation, termination and testing. This work shall be provided by Owner. Refer to Appendix A – RoD Network Specifications – 2020.

1.2 Dimensions and quantities

.1 Dimensions shown on Drawings are approximate. Verify dimensions by reference to shop drawings and field measurement.

.2 Quantities or lengths indicated in any of the Contract Documents are approximate only.

.3 Make necessary changes to routing of cables and the like to accommodate structural, mechanical, electrical and architectural conditions. Coordinate with other trades and make allowance for conditions that will arise from work in progress under separate contract.

.4 Plan cable pathway routing to ensure compliance with cable performance specifications, reference standards, and to avoid electromagnetic interference effects.

.5 Report to the engineer immediately upon identification of any condition that may result in the performance criteria of the cabling being compromised.

1.3 Working drawings and documents

.1 Where the word "HOLD" appears on Drawings and other Contract Documents, the Work is included in the Contract. Execute such Work only after verification of dimensions and materials and obtaining Consultant's written permission to proceed.

1.4 Qualified contractors

.1 Submit a tender to undertake work described under this division only if fully qualified to undertake the work.

1.5 Quality assurance

.1 These Specifications supplement the Electrical and Electronic Manufacturers Association of Canada, Canadian Standards Association Standards, Electronic Industries Association, Telecommunications Industries Association standards and recommendations. Conditions of the EEMAC, CSA, EIA, TIA and ISO/IEC standards and recommendations apply unless superseded or modified by this Specification.

.2 Where requirements of the specifications exceed referenced standards, the specifications apply. Where standards differ between authorities, the most stringent applies.

.3 Requirements of the specifications that are substandard to referenced standards should be brought to the attention of Consultant during bidding period in sufficient time to allow suitable action to be taken and addenda issued as necessary.

.4 Equipment must be acceptable to electrical inspection authorities.

.5 Where any part of the Work fails tests, repair the fault in a manner to prevent recurrence and re-test.

.6 Where any part of the Work fails tests and that Work is to be built without physical discontinuity, remove the offending material and install new without increase in cost to the Contract.

1.6 Submittals

.1 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.2 Submit the following in accordance with Section 01 33 00 – Submittal Procedures:

.1 Shop drawings:

.1 All component types prior to their use on site.

.2 Drawing illustrating front elevation of rack layouts prior to assembling said equipment.

.3 Drawing illustrating equipment room layouts where different from contract drawings. Identify dimensions of clearances to front, rear and sides of floor mounted components.

.4 Drawings illustrating cabling identification scheme prior to use on site.

.2 Record drawings.

.3 Test reports, submit within three (3) days of testing completion.

.4 Site maintained working progress drawings for Consultant s review when requested. Site maintained copy of site instructions, change orders, change directives, minutes of site and trades coordination meetings for Consultant s review when requested.

.5 Operating and Maintenance Manuals.

.6 "As Built" Record Drawings.

.1 Prepare and submit drawings in hard copy format and in electronic machine readable computer aided drafting (CAD) format describing the work as completed. Submit drawings in AUTOCAD format of release level no older than two versions prior to current release. Request copy of standards and conventions for use when creating and maintaining CAD files. Comply with layer conventions as indicated in CAD standards and practices documentation, or use existing layering conventions in existing files when machine readable files are available.

.2 Where wires or communications raceways are underground or under floor or below finished grade, furnish field dimension with respect to building column lines and inverts with respect to finished floor levels or grades. Indicate inverts at point of penetration of conduits into below-grade hand wells, or below-grade maintenance chambers.

.3 Record deviations from cable identification shown on the Contract Drawings.

.4 Prepare records of interconnecting and cross-connecting wiring between items of equipment including equipment supplied by Owner and under other Specification Sections. Provide the records loaded into a data base. Select the data base by mutual agreement with the Consultant.

.5 Approved Data Base Products

.1 Microsoft Excel (comma delimited file)

.7 Prepare drawings clearly identifying routes taken by cable where the cable is not supported along its length by an approved electrical raceway.

.8 Submit record drawings no later than ten (10) days following submitting a claim for substantial performance.

1.7 Pathways – ducts

.1 Underground ducts per Section 26 05 43 – Electrical Site Services and Underground Ducts.

.2 Install with innerduct.

1.8 Pathways hangers and supports

.1 Supports for structured cabling to segregate cabling from electrical and mechanical sources of interference or sources of potential damage.

1.9 Grounding and bonding

.1 Comply with grounding and bonding as indicated in the contract electrical drawings.

.2 Provide Technical Single Point Ground as telecommunications systems ground reference.

.1 Grounding and bonding system for telecommunications to achieve an independent electrical grounding and bonding scheme separate and isolated from other grounds including building ground, lightning ground, process and controls ground or grounds, with exception that technical ground and electrical safety ground bonded at single point only, being closest to the source of incoming electrical power or as indicated.

.2 Technical grounding bus bars in telecommunications rooms, computer equipment rooms, telecommunications carrier building entrance and service rooms.

.3 Main technical grounding bus bar(s).

.4 Bonding conductors between technical grounding bus bars and main technical grounding bus bar as indicated using conductor of size whichever is greater of #6 AWG or as required by electrical safety code or as indicated on the contract drawings.

.5 Bonding between main technical grounding bus bar and electrical safety ground.

.6 Computer and communications equipment cabinets bonded to technical ground

.3 Common Electrical Ground

.1 Overvoltage protection building entrance devices bonded to electrical power safety ground.

.2 Communications metallic conduits, cable trays, cable runways, electrical enclosures, raceways bonded to electrical power safety ground.

.3 Grounding conductors in buried telecommunications ducts bonded to electrical safety ground.

.4 Pathways

.1 Communications cable tray, cable runway, bonded to electrical safety ground through continuous minimum 10 AWG copper conductor. Bonding at intervals of 2440 or less.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Where manufacturers are stipulated, use only the products indicated: Do not substitute with products by alternative manufacturers.

.2 Where manufacturers are indicated as preferred, use the products as the basis of the tender.

.3 Where manufacturers are identified as acceptable alternatives, voluntarily use the products as alternatives with justification for substitution and benefit to the contract.

.4 Avoid substitution of products that are not beneficial to the contract. Demonstrate benefit to the contract and obtain approval prior to use of products not stipulated in the contract drawings.

2.3 Communications grounding and bonding

.1 Use products that comply with Ontario Electrical Safety Code.

.2 Pre-drilled Copper Bus Bar

.1 Components complying with BICSI/J-STD-607A and TIA/EIA 607A

.2 Telecommunications Grounding Busbar (TGB)

.1 Type T-300

.1 300 mm TGB -Telecommunications grounding bus bar, 6.5 x 50 x 305 mm, tin plated; 6 sets holes 6 mm dia, spaced 16 mm; 3 sets of 10 mm holes spaced 25 mm, standoff insulators and mounting brackets.

.2 Manufacturer

.1 Panduit: GB2B0306TPI-1 or approved alternate.

.3 Two Hole Long Barrel Lug

.1 Components complying with BICSI/J-STD-607A.

.2 Tin plated long barrel with inspection window to confirm cable insertion; two (2) holes according to NEMA size and spacing.

.3 Manufacturer:

.1 Panduit or approved alternate.

2.4 Pathways for communications systems

.1 General

.1 Use approved electrical raceways described elsewhere in this specification with the addition of items described herein.

.2 Conduit Raceways - Data/Tel

.1 Provide EMT conduit rough-in in accordance with TIA-569 for telecommunication (data or telephone) outlets shown on drawings.

.2 Typical outlets shall be provided with a 27 mm empty conduit from outlet location to accessible ceiling space, continuing to telecom cable tray; provide pull strings in conduits.

.3 Provide single gang device box or low voltage mounting bracket at each outlet location.

.4 Provide conduit sleeves through walls (installed above ceiling) for routing of telecom cabling into rooms located off corridor.

.5 Allow for two (2) cables per outlet location.

.6 Conduits sized as follows (based on CAT6 UTP, 0.25 in. OD):

.1 27 mm (1 in.) ≈ 6 cables max

.2 35 mm (1 ¼ in.) ≈ 11 cables max

.3 41 mm (1 ½ in.) ≈ 16 cables max

.4 53 mm (2 in.) ≈ 26 cables max

.5 78 mm (3 in.) ≈ 71 cables max

.7 Confirm cable specifications with Owner prior to start of rough-in.

.3 Conduit Raceways – CATV

.1 Provide EMT conduit rough-in for cable TV (CATV) outlets shown on drawings.

.2 Typical outlets shall be provided with a 21 mm empty conduit from outlet location to accessible ceiling space, continuing to telecom cable tray; provide pull strings in conduits.

.3 Provide single gang device box or low voltage mounting bracket at each outlet location.

.4 Provide conduit sleeves through walls (installed above ceiling) for routing of telecom cabling into rooms located off corridor.

.5 Allow for one (1) cable per outlet location.

.6 Conduits sized as follows (based on RG6/U coax, 0.35 in. O.D.):

.1 21 mm (¾ in.) ≈ 2 cables max

.2 27 mm (1 in.) ≈ 3 cables max

.3 35 mm (1¼ in.) ≈ 6 cables max

.4 41 mm (1½ in.) ≈ 8 cables max

.5 53 mm (2 in.) ≈ 13 cables max

.7 Confirm cable specifications with Owner prior to start of rough-in.

.4 Cable Pathways (Fire Rated)

.1 Provide fire rated cable pathways for routing cables through walls of telecommunication rooms.

.2 Provide E-Z Path Series 44+by STI Firestop or approved alternate (approximate capacity of 210, Cat 6, 6mm OD cables) cable pathways at locations noted on drawings.

.3 Provide E-Z Path Series 33 by STI Firestop or approved alternate (approximate capacity of 88, Cat 6, 6mm OD cables) cable pathways at locations noted on drawings.

.4 Provide E-Z Path Series 22 by STI Firestop or approved alternate (approximate capacity of 15, Cat 6, 6mm OD cables) cable pathways at locations noted on drawings

.5 Cable Hangers and Supports

.1 For use only where expressly indicated as permitted

.2 Cable supports of open hook construction with 54 mm wide cable bearing surface curved with radius greater than minimum required by supported cable.

.3 Listed manufacturers and products:

.1 Basis of Design by Panduit: JMJH2-X;

.2 Other acceptable manufacturer: Ideal or approved alternate.

.4 Cable retention wraps, soft, reusable hook-and-loop tie, coloured to match colour code indicated. Plenum rated.

.1 Panduit: HLTP and HLSP series; or

.2 Approved alternate.

.6 Wire/Basket Tray

.1 Provide wire basket cable tray of types and sizes indicated with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars. Construct units with rounded edges and smooth surfaces in compliance with applicable standards.

.2 All straight section longitudinal wires shall be constructed with a continuous top wire safety edge. Safety edge must be kinked and T-welded on all tray sizes.

.3 Wire basket cable tray shall be made of high strength steel wires and formed into a standard 2 in. by 4 in. wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.

.4 Wire basket cable tray sizes shall conform to the following nominal criteria:

.1 Straight sections shall be furnished in nominal 3 m (10 ft.) lengths.

.2 Wire diameter shall be 5 mm (0.196 in.) minimum on all mesh sections.

.3 Wire tray shall have a 25 mm (1 in.) usable loading depth by 200 mm (8 in.) wide.

.5 Material and Finishes: Material and finish specifications for Carbon Steel Wire are as follows.

.1 Electro-Plated Zinc Galvanizing: Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A510, Grade 1008 and shall be electro-plated zinc in accordance with ASTM B633, Type III, SC-1.

.6 All fittings shall be field formed from straight sections in accordance with manufacturer's instructions.

.7 Wire basket cable tray supports shall be center support hangers, trapeze hangers or wall brackets as required by site conditions.

.8 Trapeze hangers or center support hangers shall be supported by ¼ in. or 3/8 in. diameter rods.

.9 Special accessories shall be furnished as required to protect, support and install a wire basket cable tray system.

.7 Conduit Guard

.1 Plastic protection press-on bushings to suit EMT and rigid galvanized steel conduit; size to suit conduit to maximum 103 diameter. Suitable for use in air supply or return plenum spaces.

.8 Flexible Corrugated Non-Metallic Conduit of nominal inside diameters 25 mm, 32 mm in fire ratings FT4, FT6.

.1 Manufacturers:

.1 Arlington or approved alternate.

.9 Flexible fabric thin wall inner duct sleeve white with colour identification stripe including pull tape in 1-, 2-, 3-cell on micro-cell format. Fire ratings of normal, riser and plenum with optional copper 18 gauge tracing strips.

.1 Listed manufacturer and products:

.1 Max cell

.1 3-cell: 103 mm MXC4003XX series

.2 3-cell: 78 mm MXC3456XX series

.3 2-cell: 53 mm MXC2002XX series

.4 Micro 2-cell: 27 mm MXCM3302XX series; or

.2 Approved alternate.

.10 Flexible Liquid-Tight Metallic Conduit

.1 Corrugated heavy gauge electro galvanized flexible steel strip helically wound conduit with integral copper bonding wire and PVC jacket, colour blue or grey in nominal inside diameter sizes 21 mm, 25 mm, 32 mm , with fire ratings FT4, FT6, to CSA C22.2 No. 0.3

.2 Manufacturers:

.1 Delikon, Type YF-604; or

.2 Approved alternate.

.11 Flexible Metallic Conduit

.1 Corrugated heavy gauge electro galvanized flexible steel strip helically wound conduit with integral copper bonding wire in nominal inside diameter sizes 21 mm, 25 mm, 32 mm.

.2 Manufacturers:

.1 Delikon, Type YF-504; or

.2 Approved alternate.

2.5 Underground ducts and raceways for communications

.1 Comply with Division 26.

.2 Rigid PVC Conduit

.1 Rigid PVC conduit manufactured to CSA C22.2 No. 211.2

.1 Rigid PVC fittings, long sweep bend

.3 Rigid Ferrous Metal Conduit with PVC Coating

.1 Rigid ferrous metal conduit to CSA C22.2 No. 45-M with PVC coating to nominal thickness of 1.02 mm conforming to NEMA publication RN1-1998

.1 Matching rigid ferrous metal PVC coated fittings and couplings; matching long sweep bends

.4 Underground Enclosure

.1 Precast polymer concrete underground enclosure

.1 Precast polymer concrete enclosure reinforced with glass fibre, to 20,000 pound loading application, open base, tamperproof cover locks

.2 Width: 305 m square; depth: 457 mm, 609 mm, 913 mm

.3 Manufacturers:

.1 Synertech or approved alternate.

3 Execution

3.1 Communications grounding and bonding

.1 General

.1 Install grounding and bonding to comply with Ontario Electrical Safety Code and all applicable codes.

.2 Install inside grounding cables and conductors in electrical raceways, cable trays, cable runways, or in rigid PVC conduits as indicated. Install outside grounding cables and conductors in PVC rigid conduit or direct buried as indicated.

.3 Install inside grounding to comply with BICSI/JSTD-607-A, TIA-607 and BICSI published Telecommunications Design Methods Manual.

.4 Install outside grounding to comply with BICSI published Customer Owned Outside Plant Manual (Latest edition).

.2 Bus Bars

.1 Mount bus bars insulated from building ground and in locations and at elevations indicated.

.2 Mount horizontally with fasteners able to resist axial pull of 50 kgf.

.3 Ensure clearance of 50 mm from other metallic objects including components of dissimilar grounding systems.

.3 Enclosures

.1 Bond communications enclosures only to telecommunications ground bus bar. Do not bond directly to electrical safety ground.

.2 For arrays of four or fewer communications cabinets, connect individual #6 grounding cables between technical grounding bus bar and individual communications cabinets.

.3 For arrays of five or more communications cabinets, connect individual #6 grounding cables between individual cabinets and a common #2 AWG insulated aisle ground cable using crimp taps. Connect aisle ground cable to technical ground bus bar using two-hole long barrel lug with window.

.4 Communications Shields

.1 Bond communication shields to technical ground at both terminations when sharing a common single point ground system. Bond communications shield to technical ground at termination distant from work area outlets when terminations do not share a common ground system.

.2 Make grounding connections to telecommunications cable conductive shields as indicated, using components designed for purpose and following manufacturer s instructions.

.3 Protect finished communications grounding against making unwanted connections to dissimilar grounding systems.

.5 Flexible conduits

.1 Bond armour and bonding wire to ground through manufactured conduit accessories.

3.2 Electrical grounding and bonding

.1 Bond electrical conduit for telecommunications, cable trays for telecommunications, cable runways directly to telecommunications ground bus (TGB).

.2 Bond metallic raceways to TGB.

.3 Provide TGB on one wall of each telecommunications room (as indicated). Provide 25 mm x 6 mm cross section 300 mm long bus mounted on standoff brackets to clear adjacent obstructions. The main telecom room shall be designated as the telecommunication main ground bus (TGMB).

.4 Provide No. 6 AWG insulated grounding conductor from TGB to ground bus to telecommunications room power distribution panel.

.5 Provide insulated grounding conductor to bond TGB to ground bus in main electrical room via TMGB, sized as per TIA 607 requirements.

.6 Provide individual No. 6 AWG insulated grounding conductors from each telecommunications cabinet or frame to the TGB.

3.3 Pathways for communications systems

.1 General

.1 Pathways laid out and installed to comply with latest release of ANSI/TIA 569.

.2 Pathways run lengths to comply with latest release of ANSI/TIA 568. Notify Engineer in event of any path length exceeding 85 m prior to installation.

.3 Inside pathways installed parallel or perpendicular to building lines.

.4 Submit drawings of proposed installation, if indicating deviation from cable routing shown on drawings to the Engineer for review prior to commencing installation.

.5 Maintain clearances from outer container of electrical and heat sources

.1 Unit substations 10 m

.2 Power transformers enclosure (greater than 30 kVA) 10 m

.3 Transformers enclosures (up to 30 kVA) 1.2 m

.4 Motors casings (greater than 1 HP) 10 m

.5 Motors casings (up to 1 HP) 1.2 m

.6 Switch gear enclosures (greater than 600 V) 10 m

.7 Feeder cable / conduit (600 V and above) 1 m

.8 Distribution cable / conduit (less than 600 V) 750 mm

.9 EMT conduit (Enclosing 30 A branch circuits) 300 mm

.10 ENT conduit (Enclosing 30 A branch circuits) 450 mm

.11 EMT conduit (Enclosing 20 A branch circuits) 75 mm

.12 ENT conduit (Enclosing 20 A branch circuits) 150 mm

.13 EMT conduit (Enclosing 15 A branch circuits) 65 mm

.14 ENT conduit (Enclosing 15 A branch circuits) 100 mm

.15 Control cabling (in separate conduit) zero

.16 Control cabling (exposed) 100 mm

.17 Class 2 wiring (in separate conduit) zero

.18 Class 2 wiring (exposed) 100 mm

.19 Conduit (All others) 75 mm

.20 Fluorescent and LED luminaires 600 mm

.21 Pipes (gas, oil, water, etc.) 300 mm

.22 HVAC (equipment, ducts, etc.) 150 mm

.2 Cable Protection

.1 Provide protective cable sleeving to prevent damage to cables at transition from cable tray, conduit, pull box, junction box, maintenance hole, pull point. Provide sleeve to reduce friction, bending and crushing forces. Install split sleeve where impracticable to install solid.

.3 Cable Hangers and Supports

.1 Where expressly indicated, support cables by use of cable hangers spaced at max 1,000 spacing.

.2 Limit cables to twenty (24) per hanger.

.3 Apply cable retention wraps without causing tension, pressure or other deformation of cable and cable bundles. Complete wrap with 100 mm overlap. Spacing between wraps not more than 1,200 mm except for cables in horizontal cable tray. Avoid wrapping cables in bundles in horizontal sections of cable tray. Secure cables in bundles in vertical portion of cables tray with supports at spacing of not more than 600 mm. Place and secure cables in tray to prevent edges pressing against cable jacket.

.4 Conduit

.1 Extend distribution and backbone conduit to cable tray.

.2 Form field-formed raceway to comply to TIA 569 specifications

.3 Fit conduit guard bushings on each exposed entrance to conduit raceway

.5 Innerduct Sleeving

.1 Install flexible corrugated non-metallic conduit for protection against abrasion and bending, and as protection of optical fibre cables in open cable tray. Colour: orange except black or grey where indicated; inside diameter: 25 mm except 32 mm where indicated; fire ratings: FT6 except FT4 where indicated

.2 Install flexible fabric low friction pre-lubricated inner duct sleeve in backbone conduits, and conduits below grade and where indicated.

Colour coded, with preinstalled pulling tape; electrically traceable where indicated

.1 3-cell construction for installation in 103 conduits

.2 3-cell construction for installation in 78 conduits

.3 2-cell construction for installation in 54 conduits

.4 Micro 2-cell construction for installation in 27 conduits

.6 Flexible Conduit

.1 Install flexible metallic liquid-tight conduit below access flooring between communications raceways and individual outlet device boxes.

.2 Install conduit of trade size as indicated on the drawings or described in the specification or 21 mm diameter whichever is the greatest.

.3 Install cable below access flooring with jacket to FT6 flame test rating.

3.4 Underground ducts and raceways

.1 General

.1 Clean out each section of duct by pulling a steel wire brush and mandrel of the correct size through the duct before pulling cables.

.2 Notify the engineer if immovable obstructions are encountered when cleaning existing ducts.

.3 Protect cable at entry and exit from ducts by flexible corrugated non-metallic conduit.

.4 Install pull string with length markers (Mule tape) in each duct and in each innerduct where applicable.

.2 Cable Placement in Underground Ducts

.1 Pull cables in underground ducts in continuous length, without splicing.

.2 Install cables in lower ducts first, leaving upper ducts for future; install cables in inner-ducts where provided.

.3 Apply only manufacturer recommended or approved lubricant to cables to reduce friction between the cable and the duct.

.4 Apply cable grips with ball bearing swivel to the cable sheath or strength members to avoid applying tensile force directly to conductors or fibres when pulling cables.

.5 Station personnel at each access point to observe and lubricate the cables during pull.

.6 Provide cable slack at manholes for expansion and contraction; mount with clips to prevent sagging.

.7 Submit tension pulling calculation prior to installation of cables to Consultant for review.

.8 Monitor cable pull tension during installation. Do not exceed maximum tensile rating of cables.

.9 Avoid bending cables to a radius less than manufacturer s recommendation, or ten (10) times the cable outside diameter, whichever is the greater.

.10 Where cable is pulled through a distance of greater than 30 m or through a pathway containing more than one 90 ° bend, use a dynamometer to record installation tension and a tension limiting device to prevent exceeding the maximum pulling tension specification during installation. Set the tension limit at or below the manufacturer's maximum limit. Take up the cable at intermediate pulling points with an intermediate cable take-up device reviewed by the Consultant.

.11 Make cable pulls continuous and steady between pull points. Avoid interruptions to the pull unless necessitated by excessive tension on the cable.

.12 Seal duct entrance into buildings with duct sealing compound to prevent the ingress of moisture, foreign materials and rodents.

End of section

1 General

1.1 Section includes

.1 Scope, system and installation of paging system and paging amplifiers are described in this Section.

.2 Scope includes:

.1 Furnish all labour, materials and all necessary appurtenances, supervision, equipment and services specified, indicated or requested to install the paging system specified herein and on the Contract Drawings.

.2 Provide an ambient noise survey for each paging area to ensure that the sound pressure level throughout the paging area is 10dB above the 'usual' ambient noise level. If additional loudspeakers are required to those indicated on Contract Drawings, provide the necessary number of loudspeakers.

.3 Provide a fully complete communication system in every respect for the purpose designated. It is hereby understood that the Contractor agrees to furnish any item not specifically mentioned but necessary to complete the installation for proper functioning of the system without extra cost.

.3 Description of system:

.1 Voice paging over all loudspeakers through VOIP telephone handsets.

1.2 Related requirements

.1 Contractor shall be responsible for co-ordinating this section with all related sections.

.2 Comply with Section 01, Section 26 05 00 – General Electrical Requirements and Section 26 05 05 – Basic Materials and Methods.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.4 Care, operation and start-up

.1 Provide instruction and demonstrate the use of the system to the owner in two scheduled training sessions (on separate dates and times). Allow for a minimum of one (1) hour for each session.

.2 Provide manufacturer's factory trained service technician to instruct:

.1 Owners representatives in the use of system

1.5 Shop drawings

.1 Submit in accordance with the General Conditions and Section 01 33 00 – Submittal Procedures .

.2 Provide a complete wiring schematic diagram, indicating the following:

.1 Location of all communications outlets, controller unit, cabinets and loudspeakers.

.2 Amplifier location and wattage size.

.3 Wattage size for each loudspeaker.

.4 Number of conductors in each conduit run.

.5 Ambient noise level and paging noise level for each area (dBs).

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 General

.1 Acceptable Manufacturers:

.1 AtlasIED;

.2 QSC;

.3 Bogen; or

.4 Approved alternate.

.2 Use equipment produced by a manufacturer with a minimum five (5) year period of experience producing similar products and who can refer to similar installations now rendering satisfactory service.

.3 Reference to model numbers and other information is intended to establish the standards of performance, quality, and appearance which must be met.

.4 Guarantee equipment to be free from defective material and workmanship for a period of one (1) year from date of final acceptance by Owner, except where damage is caused by Owner through accident, abuse, improper operation or neglect. Provide maintenance, pursuant to this guarantee during normal working hours at no expense to the Owner.

.5 Provide satisfactory evidence of the maintenance of a service organization capable of furnishing adequate inspection and service to the equipment and be prepared to offer a service contract for maintenance of the system after guarantee period.

.2 PoE IP to Analog Gateway (Zone Controller)

.1 AtlasIED IP-ZCM1RMK or approved alternate.

.2 Rack mounting.

.3 Selectable 8 ohms or 70.7V Speaker Output.

.3 Amplifier

.1 AtlasIED DPA404 or approved alternate.

.2 Mute assignment via contact closure from Fire Alarm Control Panel.

.4 Public Address Speakers

.1 Ceiling mounted (recessed) paging speakers. To be provided in areas with finished ceilings.
Assembly shall be complete with backbox, round matte white baffle, loudspeaker and impedance matching transformer assembly, suitable for flush ceiling mounting.
AtlasIED FAP33T-W or approved alternate.

.2 Surface mounted paging speakers. To be provided in open areas (no finished ceiling).
AtlasIED SM52T-WH complete with integral transformer for adjustment, or approved alternate.

.3 Wall mounted (recessed) paging speakers. 16-watt paging speaker complete with integral, screwdriver adjustable line transformer taps, 25V / 70 V line matching transformer, stainless steel mounting hardware and swivel bracket option. AtlasIED C803AT87 c/w 164-8A baffle and 191-78 backbox or approved alternate.

.4 Electrical

.1 All electrical components shall have a modular plug for easy service and replacement, and will be equipped with a fuse for protection from transient voltage conditions.

.2 Optional 120 VAC supply voltage shall be provided.

.3 The unit shall have the option for Power over Ethernet for connectivity to a VoIP network switch with 802.3af or 802.3at (minimum) capabilities. Requires the IP5000 phone for connectivity to ToolVox or SIP/IAX2 compatible VoIP system. Provide required gateway to connect to Owners phone system.

.5 Warranty

.1 The system shall be warrantied against any defects in material and workmanship, under normal use, for a period of (two) 2 years from date of Substantial Performance. If system is found by manufacturer to be defective within the warranty period, manufacturer shall repair and/or replace any defective parts, provided the equipment is returned to manufacturer.

.5 Cabling

.1 Supply and install cabling of a type and style required by the original equipment manufacturers so that the system may operate to the best of its published performance specifications.

.2 Supply and install conduit and electrical raceways for exclusive use by intercommunication system.

3 Execution

3.1 Installation

.1 Install intercom switching equipment in the main computer equipment room or as indicated on drawings.

.2 Install terminals in manner and locations indicated.

.3 Verify site conditions before commencing work.

.4 Install equipment in accordance with manufacturer's instructions.

.5 Install cable in conduit or electrical raceway. Do not use open or unsupported cabling. Use flexible conduit to enclosed link to exposed device.

.6 Make splices using insulated crimp type sleeves. Make connections to devices having screw terminals with suitable lugs crimped to ends of conductors. Do not use field soldered connections.

.7 Provide identification for wiring at outlet boxes and at accessible locations. Abide by the identification conventions as indicated in the contract.

.8 Exercise care during installation to avoid damage to cables and equipment. Replace equipment damaged or marred during installation.

.9 Permanently and clearly mark in a descriptive manner all switches, connectors, jacks, receptacles, outlets, terminal blocks and cable terminals if not already required by other parts of this specification.

.10 Take the necessary precautions to prevent and guard against electro-magnetic and electrostatic hum, to supply adequate ventilation and to install equipment so as to provide safety for the operator.

.11 Observe current standards for connecting the shield drain wire of shielded signal cables. Insulate cable shields at their terminated ends with sleeves or heat shrinkable tubing. Protect shield drain wires exiting from cable jacket by PVC or Teflon tubing.

.12 Install power wiring to electrically operated devices. Make electrical connections.

3.2 Integration

.1 Programme intercommunications system to send and receive signals to and from other systems as indicated.

.2 Provide necessary wiring and connections and make signals available to other systems to enable inter-system communications.

3.3 Tests

.1 Test entire system after completion of installation in accordance with Owner's requirements. Submit a test report to the Consultant.

.2 Verify that all equipment is properly installed and secured in place, ensure that all warning labels, covers, etc. are in place. Verify that all wiring is complete and free of all hazards and unintentional shorts. Ensure that all grounding is complete.

3.4 Training

.1 Provide training to the Owner's personnel.

End of section

1 General

1.1 Section includes

.1 Furnish and install a complete new Wireless Clock System using the Primex OneVue™ platform, or approved alternate.

.2 Furnish and install all system devices, accessories, and materials in accordance with these specifications and drawings to provide a complete and operating Wireless Clock System.

.3 System shall include the System Devices below:

.1 Digital Clocks with Power over Ethernet (PoE) technology

.2 Clock mounting hardware and accessories as required,

.3 Software

.4 PoE cabling. Provide coordination of clock installation with cabling contractor.

1.2 Related requirements

.1 Section 26 05 00 - General Electrical Requirements

.2 Section 27 05 00 - Common Work Results for Communications

.3 Contractor shall be responsible for co-ordinating this section with all related sections.

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.4 Shop drawings

.1 Submit in accordance with the General Conditions and Section 01 33 00 – Submittal Procedures.

.2 Submit in accordance with the General Conditions.

1.5 System description

.1 General

.1 System shall provide synchronized time by way of system devices and cloud-based system software hosted by the Manufacturer that allows Owner to manage and monitor system devices.

.2 System can be scaled from a single building to a network of buildings, or an enterprise spread across many time zones, providing traceable of accuracy, data and performance.

.3 System shall consist of system Bluetooth clocks enabled with Power over Ethernet (PoE) technology.

.4 System shall not require the installation of any on-site system hardware or software, with the exception of the specified system devices.

.2 System Software

.1 System software shall be accessed from a web browser and does not require the installation of software or other third-party plug-ins or applications.

.2 System users shall be able to access the system software from a web browser on a mobile or tablet device or computer with an internet connection.

.3 System software shall provide an online device configuration procedure that allows Owner supplied settings to be installed on system Non-DHCP Ethernet network devices prior to shipment from the Manufacturer.

.4 System software shall log NTP accuracy.

.5 System software shall monitor and display the operating status of system devices.

.6 System software shall provide an automated reporting method to notify system users of the operating status of system devices that may warrant corrective action.

.7 System software shall allow authorized system users to create reports, view archived reports, and set the system to automate report notifications sent to system users.

.8 System software shall maintain and store remote, redundant data backups.

.3 Encryption and Authentication specifications

.1 User software access sessions between the web browser and the system software shall be encrypted by the HTTPS protocol.

.2 The network communication of system devices enabled with Ethernet, or PoE Technology shall be secure and encrypted using the Transport Layer Security (TLS) encryption protocol and Secure Hypertext Transfer Protocol (HTTPS) authentication.

.4 System Administration specifications

.1 Software interface shall allow the Owner's system admin user(s) to manage the system components, including: system device settings, reports, system-wide user password complexity settings and user session timeout setting to align with Owner information security policies and procedures, manage system users and grant user access to system data and features, activate and deactivate system users, and view user log in history.

.2 System software shall allow each system user to manage their own system profile, including their log in email address, password, and contact settings.

.3 System software shall allow system device settings to be user-defined to meet Owner requirements.

.4 System software shall allow devices that use a Non-DHCP Ethernet network connection to be assigned to a primary and alternate network for failover purposes. Network settings are managed within the system software, allowing remote management to migrate devices from one network to another.

.5 System software shall allow user-defined reporting; system shall store and present system historical data in the form of system reports. User-defined data shall include the system devices included in a report, the frequency a report is system generated,

and a specific range of data included in a report. System reports shall be displayed in the system software electronically within the interface allow a system user to print and download reports. System shall allow report data to be restricted based on the role(s) assigned to a system user profile.

.5 System devices with Ethernet network communication specifications

.1 Network Communication Protocols: Hypertext Transfer Protocol Secure (HTTPS) | IP Addressing: Dynamic Host Configuration Protocol (DHCP), static IP addressing | Data Packet Size: typically less than 5 kilobytes (kB)

.2 Network setting data is stored locally in devices shall be encrypted and access to locally stored setting data can be controlled by a system admin user.

.3 Manufacturer shall provide stand-alone configuration software to locally configure a device to meet Owner security policies if network setting data cannot be stored in third-party software or to troubleshoot device network connectivity issues.

1.6 Quality assurance / substitutions

.1 Alternate Manufacturer Qualifications: Manufacturer of wireless and Ethernet connected system with a minimum of ten years record of satisfactory manufacturing and support of systems comparable to basis of specified system design.

.2 Proposed substitutions, to be considered, shall be manufactured of equivalent materials that meet or exceed specified requirements of this Specifications.

.3 Proposed substitutions shall be identified not less than ten (10) days prior to bid date.

1.7 Delivery, storage and handling

.1 Deliver all components to the site in the Manufacturer’s original packaging.

.2 Packaging shall contain Manufacturer name and address, product identification number, and other related information.

.3 Store equipment in finished building and in unopened packaging until ready for installation.

1.8 Project site conditions

.1 System design is integrated with Owner's existing network, wired Ethernet or PoE network; limited to devices equipped with Ethernet/PoE technology.

.2 Conductors and Cables: Comply with requirements of Section 27 05 00 - Common Work Results for Communications.

.3 Signal and Control Circuits: Manufacturer recommended stranded, single conductors, or twisted- pair cables.

.4 Data Circuits: Category five (5) minimum, twisted-pair cable.

1.9 Warranty

.1 Manufacturer shall provide a two year limited warranty starting from date of Substantial Performance for Clock devices equipped with Power over Ethernet (PoE) technology.

.2 Manufacturer shall offer an extended warranty on system devices.

1.10 Software maintenance

.1 The Manufacturer shall offer an annual Technical Support Agreement (TSA); agreement shall be inclusive to system software access, phone/email technical support, software maintenance and revisions, and firmware revisions.

.2 All system updates, enhancements and maintenance are performed per agreed upon TSA.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 System software

.1 Basis of Design Software Product: Primex OneVue™ Wireless Clock System, or approved alternate.

.2 System Software Platform: Cloud-based software platform that resides on Amazon Web Services (AWS) and is accessed via the internet.

.3 System stores and monitors system devices operating conditions.

.4 All system device and system settings are managed within the system software.

2.3 Digital Clocks

.1 Digital Clocks shall meet the following specifications:

.1 The clock LED display must include a twelve (12) or twenty four (24) hour time display, a PM indicator light, and an alternating time and date display option.

.2 A dual-mount kit shall be provided (where indicated on drawings) from the Manufacturer that combines two single clocks to allow for a dual-sided clock.

.3 Clocks shall be capable of automatically adjusting for Daylight Saving Time.

.4 Power over Ethernet (PoE) model shall have an IEEE 802.3af compliant power supply built into the clock assembly.

.5 Clocks shall have a power outage memory backup and maintain correct time up in its memory for a minimum of 1 hour without power.

.6 Clocks shall be viewable from 150 ft. (45.7 m).

.7 Clocks shall have highly visible seven (7) segment LED digits.

.8 Clocks shall have display dimmer options, including 100 %, 75 %, 50 %, and 25 %.

.9 Clock enclosures shall be ABS plastic and junction box shall be UL listed (UL 50E 1st Ed; listing number E469550).

.10 Digital Clock model

.1 Surface Mounted (Ceiling or Wall)

.2 4 in. (100 mm) Digits

.3 Technology: Power over Ethernet (PoE)

.4 Clock Power: PoE, 802.3 at/af compatible

.5 Number of Digits: six (6) Digit

.6 Digit Color: Green

.7 Bracket: 4 ° Slope Bracket

.11 Polycarbonate clock guards to be provided where required.

.12 Clocks to be suitable for damp environment where located near vehicle wash down areas.

3 Execution

3.1 Examination

.1 Examine conditions with the Installer present for compliance with requirements and other conditions affecting the performance of the system and the system devices.

.2 Do not proceed until unsatisfactory conditions have been corrected.

.3 Verify that construction is complete in spaces to receive equipment and that rooms are clean and dry.

3.2 Installation

.1 General: Install system devices in accordance with applicable codes.

.2 Install system devices in accordance with Manufacturer written instructions.

.3 Provide all system equipment necessary for a complete and operable system.

.4 Comply with requirements of Division 27 Sections "Common Work Results for Communications" and "Communications Horizontal Cabling."

.5 Cables: Cabling shall be installed under separate contract as directed by the Owner. Coordinate raceway installation to clocks for installation of cabling.

3.3 Field inspection

.1 Inspection: Make observations to verify that system devices and components are properly labeled.

.2 Prior to final acceptance, inspect each system device and component, adjust as required, and replace parts which are found defective.

.3 At completion of system device installation and prior to final acceptance, turn on the equipment; ensure that all equipment is operating properly, and that the system software and all system devices and components are functioning.

3.4 Services

.1 Manufacturer system software user guides and system device installation guides shall be provided electronically within system software.

.2 Commissioning General: Provide system commissioning in accordance with Manufacturer written recommendations. Perform operational testing to verify compliance with requirements. Adjust as required.

.3 Services shall include specified level of commissioning services:

.1 On-site commissioning service: system deployment training, including system set up, validation of device pre-configuration, system functionality, verification of device network connections, and device installation training.

3.5 Protection

.1 Protect finished installation until final acceptance of the project.

3.6 Testing

.1 All system devices must be tested at their operational installation location under normal operational conditions.

3.7 Cleaning

.1 Prior to final acceptance, clean exposed surfaces of devices, using cleaning methods recommended by Manufacturer.

3.8 Demonstration

.1 Initial Demonstration and Training: provide demonstration and training for Owner facility staff that is responsible to perform system software administration.

.2 Demonstrate maintenance procedures for system devices.

.3 Demonstrate the system software components and features, including monitoring and management of system devices.

.4 Demonstration and training shall allow for two (2) sessions at the project site (on separate dates). Each session shall allow for two (2) hours of demonstration and training.

End of section

1 General

1.1 Section includes

.1 Rough-in provisions (raceways and wiring) for card access, door contacts, electric strikes, motion detectors, LCD keypads and intrusion detection systems. Coordinate rough-in requirements with security system provider.

.2 Supply and installation of a complete and operational system, including head end equipment, card readers, proxy cards, key pads and associated wiring.

.3 Door contacts and electric strikes are provided under the hardware cash allowance.

.4 All security equipment shall be supplied and installed as per Durham Region Security Services Installation and Security System Standards.

1.2 Related requirements

.1 Contractor shall be responsible for co-ordinating this section with all related sections.

.2 “Appendix B – Security Services Installation and Security System Standards V3”.

.3 Section 28 23 00 – CCTV Equipment.

.4 Section 28 31 00 – Fire Alarm System

.5 CAN/ULC-S561-20, Installation and Services for Fire Signal Receiving Centres and Systems

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.4 Shop drawings

.1 Submit in accordance with the General Conditions and Section 01 33 00 – Submittal Procedures.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Approved Vendors

.1 Vendors to demonstrate similar size of project supply experience for a minimum of (5) years.

.2 Vendors to be certified to work on the systems required.

2.3 Materials

.1 General

.1 The Region of Durham has standardized on the ICT Integrated Access Control and Intrusion Platform running on ProtegeGX software. Shall be complete with feature expansion board and worldwide modem running the most recent firmware version.

.2 The main control panel must be an ICT PRT-CTRL-DIN panel with a PRT-PSU-DIN-2A power supply running the most recent firmware version.

.3 All AC power should be hard-wired on a dedicated 15 Amp circuit, no additional cord and plug connected device(s) should be allowed.

.4 Backup batteries for both main control panels and access door controllers should be 12V 7Ah and be labeled with the month and year of installation.

.5 All equipment shall come complete with battery backup to allow standby operation up to 24 hours after loss of power.

.6 All components shall come with a minimum 2-year warranty starting from date of Substantial Performance, inclusive of parts and labour.

.2 Fire Alarm Monitoring

.1 Provide three (3) zones for fire alarm signals to be monitored by the remote monitoring agency, LANVAC. All connections to the security system shall be ULC rated. Fire alarm signals to include:

.1 Alarm

.2 Supervisory

.3 Trouble

.3 Electric Door Strikes

.1 As specified in the Architectural door hardware schedule, otherwise

.1 Fail secure electric strikes shall be ULC listed and operate on 12VDC. Provide all power and control components for a complete and operating system.

.2 Provide electric strike power supplies, consisting of a ULC listed transformer with 120VAC input and regulated and filtered 12VDC output.

.4 Door Contacts

.1 Magnetic door contacts for monitoring of door status.

.1 Contacts shall be recess mounted (concealed) in door and frame. 1” diameter 3-wire,

.2 Capable of being wired as normally closed or normally open, installed as normally open with end of line resistor.

.3 Gap distance to be no more than 15mm in wooden frame and 25mm in steel door with recessed trough on top edge.

.2 Magnetic door contacts for monitoring of roll up (garage) door status.

.1 Contacts shall be surface mounted on top of the door or floor mounted.

.2 Tail on overhead door contact shall be armoured.

.3 Gap distance to be between 50mm and 150mm.

.5 Card Readers

.1 Card readers will be ICT V2 multi-function high security readers. They can be switch-plate or mullion mount, standard reader or arming station. Provide rough-in (box, conduit, wiring) for card

reader locations as detailed on drawings. Confirm box size and wiring requirements prior to start of rough-in.

.6 Motor Operated Doors

.1 Provide rough-in for interconnection with motor operated doors where noted on drawings.

.7 Electric Power Transfer Hinges

.1 Provide rough-in for electric power transfer hinges where double doors are to be provided with access controls.

3 Execution

3.1 Installation

.1 General

.1 Comply with the latest edition of the Ontario Building Code.

.2 Coordinate with the system suppliers and/or manufacturers prior to rough-in of the system to verify system requirements (re: box sizes and wiring).

.3 Complete Durham Region Security Services Installation Checklist with Durham Facilities Maintenance and Operations Staff.

.2 Security Control System

.1 Install headend equipment as per system provider requirements and recommendations.

.3 Door Access Control

.1 Provide rough-in of conduit, wiring and device boxes at doors as detailed on drawings.

.2 Install security devices as per manufacturer instructions.

.4 Cabling

.1 Install cables in conduits or in cable tray; conceal cable and conduits. Avoid use of exposed cables.

.2 Install wiring to conform with the requirements of the Ontario Electrical Safety Code. Size wiring in accordance with Class 2 requirements; protect wiring against mechanical injury or other

injurious conditions such as moisture, excessive heat or corrosive action in accordance with Class 1 requirements.

.3 Use wire with copper conductors.

.4 Minimum size of any conductor shall be per manufacturer's requirements.

.5 Door Strikes

.1 Comply with specifications included with architectural drawings, specifications and door hardware schedule otherwise the following:

.1 Modify frame for door to accept suitable door strike.

.2 Install door strike and align with bolt to achieve reliable and consistent operation.

.3 Set strike to required voltage.

.6 Card Readers

.1 Rough-in card readers on the public side of separation between public and secure spaces in a location as indicated.

.2 Adjust the location to suit site conditions with preference given to locating the reader near to the handle of the door.

.3 Clearly identify the proposed location for each card reader and request the Owner to review each location for confirmation of acceptability before completing the installation. Allow for relocation of the reader position (before installation) by a horizontal distance of 2 m without additional cost.

End of section

1 General

1.1 Section includes

.1 Supply and installation of a complete and operational surveillance system, including a Video Management system, cameras, motion detectors and all associated power supplies and wiring.

.2 Rough-in provisions (raceways and wiring) for all CCTV equipment. Coordinate rough-in requirements with CCTV system provider.

.3 All CCTV equipment shall be supplied and installed as per Durham Region Security Services Installation and Security System Standards.

1.2 Related requirements

.1 Contractor shall be responsible for co-ordinating this section with all related sections.

.2 “Appendix B – Security Services Installation and Security System Standards V3”.

.3 Section 28 10 00 – Card Access and Intrusion Detection System

.4 Section 28 31 00 – Fire Alarm System

.5 CAN/ULC-S561-20, Installation and Services for Fire Signal Receiving Centres and Systems

1.3 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Approved Vendors

.1 Vendors to demonstrate similar size of project supply experience for a minimum of (5) years.

.2 Vendors to be certified to work on the systems required.

2.3 Materials

.1 General

.1 The CCTV system shall be compatible with the Digital Watchdog Spectrum Video Management System complete with associated licensing.

.2 Provide network connection to Durham Region Headquarters via a modem and dedicated standard phone line.

.3 Provide network connection to Remote Monitoring Agency, LANVAC, which is a ULC compliant facility. All connections to the Monitoring Agency shall be ULC rated.

.4 Provide a global system for mobile (GSM) unit for backup communications.

.5 All CCTV devices shall be on battery backup.

.6 All CCTV equipment shall be equipped and running with the most recent version of the respective software or firmware.

.2 Surveillance system monitoring and recording

.1 Provide sufficient recording capacity for all installed cameras recording 10 frames per second, 24 hours per day, for 30 days with an extra 50% capacity for future expansion. No system shall be installed running at maximum capacity.

.2 Monitoring shall be achieved by displaying video feed of up to 16 cameras on spot monitors using Senstar Thin Clint 10D or

approved alternate. If more than 16 cameras need to be displayed on a spot monitor, an independent client computer shall be used.

.3 Provide dedicated video switches for video network terminations. Provide DLink DGS-1210-28MP switches (or most recent model) or approved alternate.

.3 UPS

.1 Provide UPS sized to handle the load of the switches and surveillance system for a period of no less than 30 minutes after loss of power.

.2 The UPS shall be capable of transmitting a simple mail transfer protocol (SMTP) notification from its own on-board network interface card

.3 Provide UPS complete with a bypass switch or other means to have batteries serviced while in operation.

.4 UPS to be Xtreme Power P80 series with optional simple network management protocol (SNMP) notification card or approved alternate.

.4 Cameras

.1 Provide cameras in locations as detailed on drawings.

.2 Spot monitors required for up to 16 cameras to be displayed should use the Senstar Thin Clint 10D or approved alternate. If more than 16 cameras need to be displayed on a spot monitor an independent client computer should be used.

.3 Standard interior fixed view camera should be AXIS P3367-V (or most current version), or approved alternate running the most recent firmware.

.4 Standard exterior fixed camera should be AXIS AXISP3367-VE (or most current version), or approved alternate running the most recent firmware.

.5 Standard mid-range exterior fixed camera should be AXIS Q1785-LE (or most current version), or approved alternate running the most recent firmware.

.6 Standard long-range exterior fixed camera should be VIVOTEKIZ9361-EH-0103 (or most current version), or approved alternate running the most recent firmware.

.7 Standard 180’ fisheye camera should be AXIS P3807PVE (or most recent version), or approved alternate running the most recent firmware.

.8 Standard PTZ camera should be AXIS Q6125LE (or most recent version), or approved alternate running the most recent firmware.

.9 Standard 360’ camera should be AXIS M3057PLVE (or most recent version), or approved alternate running the most recent firmware.

.5 Motion and Glassbreak Detectors

.1 Provide motion detectors in locations as detailed on drawings.

.2 Motion sensors shall be dual-technology sensing at a minimum (Passive Infrared + Ultrasonic detection).

.3 Sensors shall have pet immunity and tamper detection functions available.

.4 Sensors shall be able to be wired normally closed (NC) or normally opened (NO) with end of line device (EOL). Install in the field as NO with EOL.

.5 Glassbreak detectors shall have sensitivity adjustments to account for room acoustics and be adequate for the area to be covered. Available to be wired NC or NO/EOL and have tamper detection.

.6 Cabling

.1 Network cables supplied shall be RED FT6 CAT6 cables with flexible boots and be labeled at both ends.

.2 All security device wiring shall be installed in new conduits and junction boxes as per Ontario Electrical Safety Code.

.7 Raceways

.1 Provide raceways, pull boxes and junction boxes as required for installation of cabling to CCTV equipment locations as detailed on drawings.

3 Execution

3.1 Installation

.1 Install devices, wiring, and raceways to designated CCTV camera locations as detailed on drawings and as per manufacturers instructions.

.2 All devices shall be programmed with usernames and passwords supplied by the Security Services Department and no devices shall have default login and passwords left enabled.

.3 Provide pullwires in empty raceways.

.4 Install motion detectors in locations to reduce the risk of false alarm from heat sources.

.5 Focus and aim cameras to provide required views.

.6 Mount exterior cameras with hardware sized appropriately to account for maximum wind and ice loads expected on site.

End of section

1 General

1.1 Summary

.1 The minimum requirements for the Integrated Life Safety System. The system shall include, but not limited to, all equipment, materials, labour, documentation and services necessary to furnish and install a complete, operational system to include, but not limited to, the following functions:

.1 Smoke and fire detection & off-premise notification

.2 Interconnection with other building systems (elevator, air handling unit, air circulating fans, etc.)

.2 General

.1 The Contractor shall furnish all labor, services and materials necessary to install a complete, functional integrated life safety fire system. The System shall comply in all respects with all pertinent codes, rules, regulations and laws of the local jurisdiction. The System shall comply in all respects with the requirements of the specifications, manufacturer's recommendations and Underwriters Laboratories of Canada (ULC) listings.

.2 It is further intended that upon completion of this work, the Owner be provided with:

.1 Complete information and drawings describing and depicting the entire system(s) as installed, including all information necessary for maintaining, troubleshooting, and/or expanding the system(s) at a future date.

.2 Complete documentation of system(s) testing.

.3 Certification that the entire system(s) has/have been inspected and tested, is/are installed entirely in accordance with the applicable codes, standards, manufacturer's recommendations and ULC listings, and is/are in proper working order.

.3 Scope of Work: Provide and install a new fire detection and alarm system consisting of:

.1 Fire Alarm Control Panel.

.2 Manual pull stations shall be located as shown on the drawings.

.3 Area smoke detection shall be provided as shown on drawings.

.4 Duct smoke detection shall be provided as shown on the drawings.

.5 Monitor the sprinkler system water flow, pressure switches and valve supervisory switches.

.6 Provide audible appliances located throughout the building, as shown on the drawings.

.7 Provide synchronized visual appliances located throughout the building, as shown on the drawings.

.8 Provide fan shutdown controls as shown on drawings.

.9 Provide direct interface to the building automation system.

.10 Provide elevator recall functions for primary and alternate floors and elevator power shunt trip activation.

.11 Provide monitoring of standby generator (general trouble condition).

.12 Provide connection to a central station. The owner shall arrange for two dedicated phone lines to be terminated as directed by the installing contractor and one ethernet line.

.13 Provide testing and verification of fire alarm system in accordance with the requirements of CAN/ULC-S537.

.14 Provide integrated systems testing of fire alarm and fire protection systems in accordance with the requirements of CAN/ULC-S1001-11.

1.2 Related requirements

.1 Contractor shall be responsible for co-ordinating this section with all related sections.

.2 Section 28 23 00 – CCTV Equipment

1.3 Reference Standards

.1 System

.1 Ontario Electrical Safety Code

.2 Ontario Building Code

.3 Ontario Fire Code

.4 CAN/ULC-S524-14, Installation of Fire Alarm Systems

.5 CAN/ULC-S536-04, Inspection and Testing of Fire Alarm Systems

.6 CAN/ULC-S537-04, Verification of Fire Alarm Systems

.7 CAN/ULC-S561-20, Installation and Services for Fire Signal Receiving Centres and Systems

.8 CAN/ULC-S1001-11, Integrated Systems Testing of Fire Protection and Life Safety Systems

.2 Devices and Control Equipment

.1 Equipment described in the following Part 2 Section must be listed under the current issue of the standard indicated

.2 Manual Fire Alarm Stations: CAN/ULC-S528

.3 Heat Detectors: CAN/ULC-S530

.4 Smoke Detectors: CAN/ULC-S531

.5 Audible Signal Devices: CAN/ULC-S525

.6 Control and Related Equipment: CAN/ULC-S527

.7 Visual Signals: CAN/ULC-S526

1.4 Verification

.1 At the completion of the installation provide two letters of certification one from the electrical sub-contractor and one from the system manufacturer's representative. Each on company letterhead and signed by an authorized officer of the company. Each letter shall indicate the following:

.1 The name of the system

.2 The name of the facility

.3 The correct address of the facility

.4 A statement that the system has been installed and that it operates in accordance with the drawings and specifications and that the system was found to be in proper operating conditions

1.5 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

1.6 Shop drawings

.1 Submit in accordance with the General Conditions and Section 01 33 00 – Submittal Procedures.

.2 A complete description of system architecture and operation.

.3 Detailed riser diagrams identifying all devices including but not limited to locations of isolation modules required by code, conductors, raceways, initiating zones, signaling circuits and terminations. A complete listing of all devices to be annunciate on the LCD display. Listing shall include device address, type and descriptive label.

.4 Step-by-step operating sequence, cross referenced to logic flow diagram.

.5 Calculation showing battery capacity for the require operation to meet code requirements.

.6 Integrated Systems Testing Plan and Report as per latest issue of CAN/ULC-S1001-11.

.7 Submit fire alarm system testing and verification report within project Operating and Maintenance Manuals.

1.7 Warranty

.1 The Fire Alarm / Life Safety System manufacturer shall supply a two (2) years warranty from date of Substantial Performance for all control system, field devices, and appliances. Contractor shall warrant the installed system to be free from any defects of material and installation for a period of two (2) years from date of Substantial Performance.

.2 Any deficiencies shall be immediately corrected at no additional cost to the owner.

.3 The Fire Alarm Manufacturer's authorized service organization shall provide a separate maintenance contract for a period of two years from the date of system commissioning. As part of the systems maintenance,

the service company will provide printed reports which detail the sensitivity of each smoke detector installed in the system, and the date of the report.

2 Products

2.1 Materials – Sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 System and Manufacture

.1 Subject to compliance with requirements specified in this Section, Products from the following manufacturers are acceptable:

.1 Mircom (basis of design);

.2 Chubb Edwards;

.3 Tyco Simplex-Grinell; or

.4 Approved alternate.

.2 All equipment and components shall be the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system. The contractor shall provide, from the acceptable manufacturer's current product lines, equipment and components, which comply, with the requirements of these specifications.

2.3 System operation

.1 Single Stage Alarm Operation

.1 Upon alarm activation of any area smoke detector, heat detector, manual pull station, sprinkler water flow, the following functions shall automatically occur:

.1 Turn on the respective red alarm LED and display the activated device at the control panel located in the vestibule as indicated on the plans

.2 Cause auxiliary contacts to activate door release, shut down fans, elevator recall, etc.

.3 Activate the common alarm contact to notify the local fire department or approved central monitor station

.4 A pulsing alarm signal tone shall occur within the control panel and annunciator(s)

.5 Cause the alarm signal devices to sound throughout the building until silenced

.6 Cause any visual signal device if required on plans to activate

.7 The following actions shall occur simultaneously:

.1 Activate audible horns throughout the building (general alarm evacuation).

.2 Activate visual strobes throughout the building (general alarm evacuation). The visual strobe shall continue to flash until the system has been reset. The visual strobe shall not stop operating when the "Alarm Silence" is pressed.

.2 Duct Smoke Activation - Alarm

.1 Upon alarm activation of any duct smoke detector, the following functions shall automatically occur:

.1 The internal audible device shall sound at the control panel or command center.

.2 The LCD display shall indicate all applicable information associated with the alarm condition including; zone, device type, device location and time/date.

.3 Transmit signal to the building automation system.

.4 Transmit signal to the central station with point identification.

.5 Shutdown the local air handling unit.

.3 Supervisory Operation

.1 Upon supervisory activation of any sprinkler valve supervisory switch, sprinkler pressure switch, or emergency generator trouble condition, the following functions shall automatically occur:

.1 The internal audible device shall sound at the control panel or command center.

.2 The LCD display shall indicate all applicable information associated with the supervisory condition including; zone, device type, device location and time/date.

.3 Transmit signal to the central station with point identification.

.4 Trouble Operation

.1 Upon activation of a trouble condition or signal from any device on the system, the following functions shall automatically occur:

.1 The internal audible device shall sound at the control panel or command center.

.2 The LCD keypad display shall indicate all applicable information associated with the trouble condition including; zone, device type, device location and time/date.

.3 Transmit signal to the central station with point identification.

2.4 Control panel

.1 Single stage operation, fully addressable on all alarm and trouble initiating devices.

.2 The control panel shall be a multi-processor based networked system designed specifically for fire monitoring and alarm.

.3 The control panel shall be listed and approved as one system for the application standard(s) as listed under the General section.

.4 The control panel shall include all required hardware, software and site specific system programming to provide a complete and operational system.

.5 The control panel(s) shall be designed such that interactions between any application can be configured, and modified using software provided by a single supplier.

.6 The system control unit shall be a Mircom Model number FX-2003-12DS(12amp) or approved alternate. The control unit shall contain the microprocessor system operating software and non-volatile programmed memory. The unit shall be used to process all system information. In addition, any of the above mention system control units shall contain four (4) standard audible/visual signal circuits with option to add signals explain herein. The panel also to have municipal tie circuits, alarm and trouble contacts.

.7 There shall be minimum (12) spare zones available, in addition to the zones specified on the contract drawings.

.8 The system control shall contain one (1) Intelligent analog loop base. Loop shall be connected in a Class A Style configuration. Loop wiring shall be via a twisted, unshielded pair with wire gauge to be determined by the following: Max. 40 ohms loop resistance and Max. of 0.5uf capacitance. Each loop shall be capable of communicating with up to 99 addressable sensor devices and 98 monitor output devices (198 points per loop).

.9 Store all system functionally and job specific data in non-volatile memory. System is to survive a complete power failure intact.

.10 FX-2003-12DS System control units or approved alternate shall be capable of supporting up to two (2) internal annunciation or programmable modules and three (3) conventional hardwired adder modules (any combination of signal, detection or relay modules) and/or four (4) additional intelligent analog loops.

.11 Provide a LCD Display Module of membrane style construction with a 4 line by 20 character Liquid Crystal Display. Use supertwist LCD technology and backlighting for high contrast visual clarity. In normal mode display the time, date, and system condition and user definable message.

.12 BAS monitoring integration

.1 Coordinate with BAS system provider for interconnecting wiring between Fire Alarm Control Panel and BAS system for the following signals as a minimum:

.1 Alarm

.2 Supervisory

.3 Trouble

.13 Public Address System integration

.1 Provide output signal to Public Address System amplifier to mute all announcements during a fire alarm event.

2.5 Power supply

.1 System power supply(s) shall provide multiple power limited 24 VDC output circuits as required by the panel. Upon failure of normal (AC) power, the affected portion(s) of the system shall automatically switch over to secondary power without losing any system functions. Each system power supply shall be individually supervised. Power supply trouble signals shall identify the specific supply and the nature of the trouble condition. All standby batteries shall be continuously monitored by the power supply. Low battery and disconnection of battery power supply conditions shall immediately annunciated as battery trouble and identify the specific power supply affected.

.2 All system power supplies shall be capable of recharging their associated batteries, from a fully discharged condition to a capacity sufficient to allow the system to perform consistent with the requirements of this section as per ULC. All AC power connections shall be to the building's designated emergency electrical power circuit and shall meet the requirements of OESC. The AC power circuit shall be installed in conduit raceway. The power circuit disconnect means shall be clearly labeled FIRE ALARM CIRCUIT CONTROL and shall have a red marking. The location of the circuit disconnect shall be labeled permanently inside the each control panel the disconnect serves.

2.6 Initiation devices

.1 Manual Pull Stations

.1 Fire Alarm / Life Safety System shall incorporate single stage microprocessor-based addressable Manual Pull Stations connected over a two (2) wire electronic communications loop, using both broadcast and serial polling protocols. All Manual Pull Stations shall display communications and alarm status via LED’s mounted on their integral, factory assembled module.

.2 All addressing of the Manual Pull Stations shall be done electronically, and the electrical location of each station shall be automatically reported to the Fire Alarm Control Panel, where it may be downloaded into a PC, or printed out. The addressing of the Manual Pull Station will not be dependent on their electrical location on the circuit.

.3 All Manual Fire Alarm station shall be suitable for operation in the following environment:

.1 Temperature: 32 °F to 120 °F (0 °C to 49 °C)

.2 Humidity: 0-93 % RH, non-condensing

.4 Manual Pull Stations indicated to include an auxiliary contact for direct wiring to the local electromagnetic lock shall be normally closed (N.C.) type.

.2 Smoke Detectors

.1 The smoke detector shall be photoelectric type, microprocessor based, intelligent detector:

.1 Plug-in type with intelligent fixed base

.2 Wire-in base assembly with integral red alarm LED

.3 Automatic environmental compensation

.4 Variable sensitivity setting

.5 Dirty sensor indication

.6 Devices to be fully addressable

.3 Duct Smoke Detectors

.1 Photoelectric type complete with duct casting and sampling tubes for installation in air system

.2 Same features as smoke detector above.

.3 Provide remote test stations for all duct detectors. Test station shall consist of alarm indicator LED and key operated test switch.

.4 Devices to be fully addressable.

.5 Complete with relay to shut-down associated mechanical equipment.

.4 Heat Detectors

.1 Plug-in type with fixed base

.2 Rate-of-Rissse and fixed temperature

.3 Microprocessor based

.4 Fully addressable

2.7 Notification devices

.1 General

.1 All appliances which are supplied for the requirements of this specification shall be ULC Listed.

.2 All appliances shall be of the same manufacturer as the Fire Alarm Control Panel specified to ensure absolute compatibility between the appliances and the control panels, and to ensure that the application of the appliances are done in accordance with the single manufacturer's instructions.

.3 Any appliances that do not meet the above requirements, and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100 % compatible with each other for the purpose intended.

.2 Self-Synchronized Horns and Strobes

.1 Provide electronic horns, strobes and combination horn/strobes as indicated on the plans.

.2 Horn and strobe power shall be provided on one pair of wires. It shall be possible to control the horn (on, off and coded) independently from the strobe.

.3 The horn shall be selectable for continuous or synchronized temporal operation. The horn shall provide an output of 94 dB peak using a low frequency tone for superior wall penetration.

.4 The strobe shall be selectable for a continuous or temporal synchronized flash rate to match the horn and meet the intent of the Ontario Building Code, Appendix Clause 3.2.4.20 (1). The strobe output shall be synchronized and available in 15, 30, 60, 75 &110 candela (cd) as listed on the plans. The light output shall be an

even “Full Light” pattern throughout the strobes protected area. Strobes utilizing a traditional specular reflector with uneven light distribution are not acceptable.

.5 The horn/strobe shall be an ultra-low profile single gang design, finished in UV stable textured red and shall not protrude more than 1” from the wall.

.6 All mounting hardware shall be captive and there shall be no mounting screws visible after the device is installed. The devices shall mount to a standard single gang electrical box and have an optional trim ring for 2-gang, octagonal or 4 in. square boxes. The signalling device series shall share a common appearance and be available in a horn, strobe or combination horn/strobe unit as listed on the plans.

2.8 Intelligent modules

.1 General

.1 Fire Alarm System shall incorporate microprocessor-based addressable modules for the monitoring and control of system Input and Output functions over a two (2) wire electronic communications loop, using both broadcast and serial polling protocols.

.2 All modules shall display communications and alarm status via LED indicators. The function of each connected module shall be determined by the module type, and shall be defined in the system software through the application of a personality code. All addressing of the Microprocessor-based Addressable Modules shall be done electronically, and the electrical location of each module shall be automatically reported to the Fire Alarm Control Panel, where it may be downloaded into a PC, or printed out.

.3 The addressing of the modules will not be dependent on their electrical location on the circuit. All field wiring to the Microprocessor-based Addressable Modules shall be supervised for opens and ground faults and shall be location identified to the module of incidence. Diagnostic circuitry, and their associated indicators, with reviewable Trouble Codes, shall be integral to the Microprocessor-based Addressable Modules to assist in troubleshooting system faults.

.4 Each module shall be suitable for operation in the following environment:

.1 Temperature: 32 °F to 120 °F (0 °C to 49 °C)

.2 Humidity: 0-93 % RH, non-condensing

.2 Single Input Module:

.1 Microprocessor-based Addressable Modules shall be used to provide one (1) supervised Class B (style B) input circuit capable of latching operation for use with contact devices, non-damped water flow switches, non-latching supervisory sprinkler switches.

.3 Dual Input Module:

.1 Microprocessor-based Addressable Modules shall be used to provide two (2) independent supervised Class B (style B) input circuits capable of operation with contact devices. Both of the input circuits shall be terminated to, and operated from, the same microprocessor-based addressable module.

.2 Modules configured for water flow operation shall have an automatic delay of fifteen (15) seconds before reporting the water flow alarm condition to the Fire Alarm Control Panel. The module shall monitor sprinkler supervisory switches and shall automatically report the supervisory function to the Fire Alarm Control Panel each time the associated dry contact closes.

.4 Monitor Module:

.1 The Microprocessor-based Addressable Monitor Module shall be factory set to support one (1) supervised Class B Normally-Open Active Non-Latching Monitor circuit. The module shall automatically report the monitor function to the Fire Alarm Control Panel each time the associated dry contact closes.

.5 Control Relay Module:

.1 Microprocessor-based Addressable Control Relay Modules shall provide one form “C” dry relay contact rated at 2 amps @ 24 Vdc or 0.5 amps at 120 VAC to, control external appliances or equipment processes. The control relay module shall be rated for pilot duty

applications. The position of the relay contact shall be confirmed by the system firmware.

.6 Universal Class A/B Module,

.1 The Microprocessor-based Addressable Module Universal Class A/B Module shall be capable of a minimum of fifteen (15) distinct operations. The universal class A/B module shall support one of the following circuit types:

.1 Supervised Class A/B Normally-Open Alarm (Active) (Delayed) (Non-) (Latching).

.2 Form “C” dry relay contact rated at 2 amps @ 24 Vdc.

.3 Supervised Class A/B 2-wire Smoke Alarm (Verified)

.4 Supervised Class A/B Signal Circuit, 24Vdc @ 2 A.

.7 Universal Input/Output Module Support

.1 Enclosure to provide mounting and wiring terminations for up to six (6) addressable modules. The motherboard design shall provide two riser inputs that are common to all modules.

2.9 Accessories

.1 Weatherproof Covers

.1 Where noted on drawings, provide protective covers for devices located in wet or damp locations.

.2 STI Stopper or approved alternate as recommended by fire alarm system manufacturer.

.2 Fire Alarm Passive Graphic

.1 Full colour mylar film of building indicating street, building floors and fire alarm zones corresponding to the fire alarm control panel. Provide a solid backing and enclose in an extruded aluminum metal frame with a minimum 1/8 in. (3 mm) Plexiglas cover. Graphic is to bolted or screwed securely to the wall in location(s) as indicated on drawings. Graphic must be approved by Consultant and local fire authorities before manufactured.

.2 Provide a graphic adjacent to the control panel.

2.10 Fire alarm wires and cables

.1 Audio/Visual Signal Circuit Wiring - solid copper conductors, type FAS105, rated 600Volt XLPE insulation in approved raceways. Minimum #14 AWG.

.2 Addressable loops and Initiation Circuit Wiring – solid copper conductors, type FAS105, 300V PVC flame retardant jacket, shielded. Canada Wire – Securex or approved alternate. Minimum wire size shall be #18 AWG.

.3 Coordinate and confirm fire alarm system wiring requirements with fire alarm system manufacturer.

3 Execution

3.1 Installation

.1 The entire system shall be installed in accordance with the latest edition of CAN/ULC-S524 and the approved manufacturer's manuals and wiring diagrams.

.2 The contractor shall furnish all labour, conduit, wiring, outlet boxes, junction boxes, cabinets and similar devices necessary for a complete, functional life safety fire alarm system.

.3 Provide all necessary power supply, interconnecting and remote signal wire in dedicated conduit throughout and installed in accordance with the manufacturer's wiring diagrams and the requirements of the Ontario Electrical Safety Code and the Electrical Safety Authority.

.4 All penetration of floor slabs and fire walls shall be fire stopped in accordance with all local fire codes.

.5 Wiring for fire alarm system shall be installed in metallic raceways (EMT conduit unless noted otherwise). Flexible metallic raceways may be utilized for drops to devices installed in drop ceilings (length not to exceed 3,000 mm).

.6 Install wiring for alarm initiating circuits in separate raceway system from the alarm signal circuits.

.7 Splicing of conductors is not permitted under any circumstances.

.8 Wire all alarm signals in accordance with requirements by manufacturer and operation. Install resistor for signal circuit in suitable box adjacent to last signal device. If diodes are used, install in outlet box of last signal device of signal circuit and indicate on signal.

.9 Isolation modules shall be furnished as required for site specific conditions.

.10 Provide required number of signal circuits and wire alternatively. Meaning that signals on same circuit shall not be horizontally adjacent to each other.

.11 Ensure continuity of ground through all raceways from ground buss in control panel to each device junction box.

.12 Clear all wiring of shorts, opens and grounds on completion of work.

.13 Mount detectors on ceiling as per latest edition of CAN/ULC-S524 standard unless otherwise specified herein with minimum and maximum distances as required for respective type of detector, at highest point where variations in ceiling height exist. Do not mount detectors on sides, undersides, or less than 450 mm from walls, beams, joints, ducts, open web steel joists or any obstruction (projecting more than 100 mm below actual ceiling height). Do not mount detectors less than 450 mm from air handling outlets or air exhaust inlets.

.14 Should interference from obstruction, lamp positions, air outlets or heat radiating surfaces be encountered in locating any detector where shown, locate detector as near as possible to shown position, clear of obstacles, but maintain a clear space of 450 mm on ceiling, below and around.

.15 Identify signal circuit, alarm initiating circuit, auxiliary circuit and all other wiring at fire alarm control panel, annunciator, terminal boxes or elsewhere on completion of work with appropriate marking labels. Mark single conductors with suitable self-adhesive type, indelible numbered markers, identify cables with a clear polyester tag, attaches with a self-locking TY-RAP.

.16 Provide, install and connect wiring and interconnecting wires and cables as specified herein, as required by control panel manufacturer and as shown on Drawings.

3.2 Field quality control

.1 Only directly prior to verification, all smoke detector protection shall be removed, and all smoke detectors shall be thoroughly cleaned.

.2 The manufacturer's representative shall make an inspection of the fire alarm equipment, including those components necessary to the direct operation of the system such as manual stations, thermal and smoke actuated detectors and controls, whether or not manufactured by the manufacturer. The inspection shall comprise an examination and test of such equipment for the following:

.1 That the type of equipment installed is that designated by the specifications.

.2 That the wiring connections to all equipment components show that the installer undertook to have observed ULC requirements.

.3 That all products of combustion (smoke) detectors have been properly calibrated and adjustments set correctly.

.4 That the representatives equipment has been installed in accordance with the manufacturer's recommendations.

.5 That the supervisory wiring of all devices connected to a supervised circuit is operating and that the wiring, having been met to the satisfaction of the inspecting officials.

.3 Testing to be done in the presence of the local building inspector and the local fire Marshall. Fire alarm system shall be verified as per the latest issue of CAN-ULCS537 Verification of Fire Alarm Systems standard.

.4 Arrange with Consultant, manufacturer of control equipment and all other installers of related and connected equipment to have a final functional acceptance test, giving ample notice to all parties concerned to be present.

.5 Provide two (2) - 2.0 hour (four (4) hours total) familiarization and instruction period, to familiarize user and/or appointed representatives, with working and function of system and equipment.

.6 All testing methods are to be ULC approved. Do not use open flame or methods which will damage detectors. All testing methods are to be approved by the engineer prior to actual testing.

3.3 Demonstration and training

.1 Provide two (2), two (2) hour (four (4) hours total) familiarization and instruction sessions, to familiarize user and/or appointed representatives, with working and function of system and equipment. Sessions shall be scheduled on separate days.

End of section

1 General

1.1 Section includes

.1 This section specifies the requirements for supplying and processing aggregate materials to be stockpiled or incorporated into work. Specific material requirements of the aggregates are included in other related sections.

1.2 Related requirements

.1 Section 31 23 33 – Excavating, Trenching and Backfilling

.2 Section 32 11 23 – Aggregate Base Courses

1.3 Reference standards

.1 Latest version of the American Society for Testing and Materials (ASTM) International Standards:

.1 ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.2 ASTM D698-12e2, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft. lbf/ft^3 (600 kN-m/m^3)).

.2 Latest version of the Ontario Provincial Standards and Specifications (OPSS):

.1 Ontario Provincial Standard Specification OPSS.MUNI 1010 “Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material”.

.3 MOECP Soil, Groundwater and Sediments Standards for use under Part XV.1 of the EPA.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Submit aggregate material to the Testing Agency within fifteen (15) days prior to the start of the work and prior to mobilization. Do not deliver or use aggregate materials until approved by the Testing Agency.

.1 Product Data: Submit supplier/source information, data sheets, description of the aggregate material characteristics (origin and material composition), list of each type of aggregate material to be used, and their limitations.

.2 Prequalification Tests: Submit prequalification testing reports for all aggregate materials. Refer to specifications listed below for additional information pertaining to prequalification testing for each aggregate type.

.1 Section 31 23 33 – Excavating, Trenching and Backfilling

.2 Section 32 11 23 – Aggregate Base Courses

.3 Aggregate Plan: A plan which describes the handling, transportation, processing, and stockpiling for aggregate materials.

.1 Specify which aggregate materials will be imported and which materials will be produced onsite.

.2 Include a list of the major pieces of equipment which are to be used.

.4 Layout and Stockpiling Plan: A figure that shows the access locations, haul routes, transportation wayfinding signage and traffic control, locations of additional stockpiles and configuration of stockpiles for all aggregate materials. Indicate erosion and sedimentation control measures and dust control measures detailed on the Plan and indicate Contractor inspection and maintenance requirement (i.e. frequency, triggers for repair, etc.).

1.5 Quality assurance

.1 Testing Agency: Owner will retain a Professional Engineer, registered in the Province of the work, to provide testing and inspection services for the work of this Section according to applicable codes, standards and Contract Documents.

.2 Source Quality

.1 Inform the Testing Agency of proposed source of aggregates and provide access for sampling 4 weeks minimum before starting production.

.2 If materials from proposed source do not meet, or cannot reasonably be processed to meet, specified requirements, locate alternative source.

.3 Advise the Testing Agency four (4) weeks minimum in advance of proposed change of material source.

.4 Acceptance of material at source does not preclude future rejection if it fails to conform to requirements specified, lacks uniformity, or if its field performance is found to be unsatisfactory.

.3 Sampling

.1 Allow continual sampling by Testing Agency during production.

.2 Provide the Testing Agency with access to source and processed material for sampling.

.3 Provide front end loader or other suitable equipment including trained operator for stockpile sampling as necessary. Move samples to storage place as directed by the Testing Agency.

.4 Supply new or clean sample bags or containers according appropriate to aggregate materials.

.5 Pay cost of sampling and testing of aggregates which fail to meet specified requirements.

.4 Acceptance

.1 The Testing Agency reviews and approves all submittals pertaining to aggregate materials prior to the processing of materials and delivery to the site.

.2 The Consultant reserves the right to request the Testing Agency to select and test any aggregate material randomly from the material supplier or stockpiled location to verify material conformance.

.5 Certifications:

.1 Submit confirmation by the Testing Agency that materials and installation complies with the Contract Documents.

.6 Test Data:

.1 If requested by Consultant, submit test data verifying that specified requirements are being met. Test results may be from a previous testing program conducted on a system similar to that specified herein.

1.6 Delivery, storage and handling

.1 Deliver, store and handle materials according to Section 01 65 00 – Product Delivery Requirements.

.2 Transportation and Handling: Handle and transport aggregates to avoid segregation, contamination and degradation. Keep all stockpiles free of snow and ice.

.3 Storage: Keep storage area clean, firm, smooth, and well drained so that the aggregate can be recovered free from dirt and other foreign matter. Store washed materials or materials excavated from underwater twenty four (24) hours minimum to allow free water to drain and for materials to attain uniform water content.

1.7 Waste management and disposal

.1 Keep aggregate stockpiles, processing area, haul routes, and stone placement regions clean and free of debris.

.2 Remove and dispose of all unsuitable materials and aggregate materials that do not meet the requirements of this specification. Dispose of unsuitable aggregate materials to an onsite or offsite location, as identified by the Testing Agency.

.3 Waste Management: separate waste materials for recycling according to Section 01 74 00 – Cleaning and Waste Management.

.1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Aggregate quality: Sound, hard, durable material free from soft, thin, elongated or laminated particles, organic material, clay lumps or minerals, free from adherent coatings and injurious amounts of disintegrated pieces or other deleterious substances.

.2 Flat and elongated particles of coarse aggregate according to ASTM D 4791-10.

.1 Greatest dimension not to exceed five (5) times the least dimension.

.3 Provide one fine aggregates satisfying requirements of applicable aggregate specifications, or the blend of following listed below. Refer to the appropriate aggregate specification for restrictions. Provide all other fine aggregates according to the appropriate OPSS specification.

.1 Screenings produced in crushing of quarried rock, boulders, or gravel.

.2 Reclaimed asphalt pavement, if permitted for intended use.

.3 Reclaimed concrete material, if permitted for intended use.

.4 Provide one coarse aggregates satisfying requirements of applicable aggregate specifications, or the blend of following listed below. Refer to the appropriate aggregate specification for restrictions. Provide all other coarse aggregates according to the appropriate OPSS specification.

.1 Gravel and crushed gravel composed of naturally formed particles of stone.

.2 Light weight aggregate, including slag and expanded shale, if permitted for intended use.

.3 Reclaimed asphalt pavement, if permitted for intended use.

.4 Reclaimed concrete material, if permitted for intended use.

3 Execution

3.1 Examination

.1 Verification of Conditions: Verify that conditions are acceptable for topsoil stripping and aggregate stockpiling.

.1 Visually inspect substrate in presence of the Testing Agency.

.2 Inform the Testing Agency of unacceptable conditions immediately upon discovery.

.3 Proceed with topsoil stripping only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Testing Agency.

3.2 Preparation

.1 Stockpiling:

.1 Stockpile aggregates on site in locations as indicated unless otherwise directed by the Testing Agency or Owner. Do not stockpile on completed pavement surfaces or surfaces not properly prepared.

.2 Any method of placing aggregates in stockpiles, which in the opinion of the Testing Agency, breaks, degrades, or otherwise damages the aggregate, will not be permitted.

.3 Stockpile aggregates in sufficient quantities to meet project schedules.

.4 Stockpiling sites to be level, well drained, and of adequate bearing capacity and stability to support stockpiled materials and handling equipment.

.5 Except where stockpiled on acceptably stabilized areas, provide compacted sand base not less than 300 mm in depth to prevent contamination of aggregate. Stockpile aggregates on ground but do not incorporate bottom 300 mm of pile into Work.

.6 Separate different aggregates by strong, full depth bulkheads, or stockpile far enough apart to prevent intermixing.

.7 Do not use intermixed or contaminated materials. Remove and dispose of rejected materials as directed by Testing Agency within forty eight (48) hours of rejection.

.8 Stockpile materials in uniform layers.

.9 Uniformly spot-dump aggregates delivered to stockpile in trucks and build up stockpile as specified.

.10 Do not cone piles or spill material over edges of piles.

.11 No equipment other than pneumatic tired equipment is permitted for processed aggregates in removing the materials from the stockpiles. Operate equipment removing materials form the face of the stockpile, in a manner to face-load from the floor to the top of the stockpile to obtain maximum uniformity of material.

.12 During winter operations, prevent ice and snow from becoming mixed into stockpile or in material being removed from stockpile.

.13 Keep roads and haul routes adjacent to stockpile free of dust and debris.

3.3 Cleaning

.1 Progress Cleaning: Leave Work area clean at end of each day.

.2 Final Cleaning: Perform upon completion to remove excess surplus materials, rubbish, tools and equipment. Move surplus or excess materials to agreed location, as directed by the Owner or Testing Agency.

.3 Leave aggregate stockpile site in tidy, well drained condition, free of standing surface water.

.4 Leave any unused aggregates in neat compact stockpiles as directed by the Owner or Testing Agency.

.5 For temporary or permanent abandonment of aggregate source, restore source to condition meeting requirements of the Owner and Authority having jurisdiction.

.6 Restrict public access to temporary or permanently abandoned stockpiles.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for clearing and grubbing in accordance with OPSS. PROV 201 and as amended by this section.

1.2 Related sections

.1 Section 31 23 33 – Excavating, Trenching and Backfilling

1.3 Reference standards

.1 Latest edition of Ontario Provincial Standard Specifications (OPSS):

.1 OPSS.PROV 201 Clearing, Close Cut Clearing, Grubbing and Removal of Surface Boulders.

1.4 Submittals

.1 Submit in according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Definitions

.1 Clearing consists of cutting off trees and brush vegetative growth to not more than specified height above ground and disposing of felled trees, previously uprooted trees and stumps, and surface debris.

.2 Close-cut clearing consists of cutting off standing trees, brush, scrub, roots, stumps and embedded logs, removing at, or close to, existing grade and disposing of fallen timber and surface debris.

.3 Clearing isolated trees consists of cutting off to not more than specified height above ground of designated trees, and disposing of felled trees and debris.

.4 Underbrush clearing consists of removal from treed areas of undergrowth, deadwood, and trees smaller than 50 mm trunk diameter and disposing of fallen timber and surface debris.

.5 Grinding consists of removal and disposal of wood below grade.

.6 Grubbing consists of excavation and disposal of stumps and roots, boulders and rocks below existing ground surface.

.7 Invasive plant material includes, but is not limited to, the following species: Norway Maple (Acer platanoides), Manitoba Maple (Acer negundo), Siberian Elm (Ulmus pumila), Common Buckthorn (Rhamnus cathartica), Glossy Buckthorn (Rhamnus frangula), Goutweed (Aegopodium podagaria), White Mulberry (Morus alba), Tree of Heaven (Ailanthus altissima), Garlic Mustard (Alliaria petiolata), Japanese Knotweed (Polygnum cuspidatum), Common Reed (Phragmites australis).

1.6 Storage and protection

.1 Prevent damage to fencing, trees, landscaping, natural features, benchmarks, existing buildings, existing pavement, utility lines, site appurtenances, water courses, and root systems of trees which are to remain.

.1 Repair damaged items to approval of Consultant.

.2 Protect existing trees and vegetation to remain from damage. If any trees to be preserved is damaged, replace at no additional cost to the Owner. Replacement cost (nursery cost plus planting cost), based on a value to be determined by the Guide for Plant Appraisal, most recent edition, produced by the Council of Tree and Landscape Appraisers.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Temporary erosion and sedimentation control

.1 Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction OR sediment and erosion control drawings.

.2 Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

.3 Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

2.3 Preparation

.1 Inspect site and verify with Consultant items designated to remain.

.2 Locate and protect utility lines: preserve in operating condition active utilities traversing site.

.1 Notify Consultant immediately of damage to or if unknown existing utility line(s) are encountered.

.2 If utility lines which are to be removed are encountered within area of operations, notify Consultant in ample time to minimize interruption of service.

.3 Notify utility authorities before starting clearing and grubbing.

.4 Erect tree protection fencing prior to commencing clearing and grubbing activities.

.5 Keep roads and walks free of dirt and debris.

2.4 Clearing

.1 Clearing includes felling, trimming, and cutting of trees into sections and satisfactory disposal of trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within cleared areas.

.2 Clear as indicated on drawings by cutting at height of not more than 300 mm above ground. In areas to be subsequently grubbed, height of stumps left from clearing operations to be not more than 1000 mm above ground surface.

.3 Cut off unsound branches on trees designated to remain as directed by Consultant.

2.5 Close cut clearing

.1 Close cut clearing to ground level.

.2 Cut off unsound branches on trees designated to remain as directed by Consultant.

2.6 Isolated trees

.1 Cut off isolated trees at height of not more than 300 mm above ground surface.

.2 Grub out isolated tree stumps.

.3 Prune individual trees as indicated as directed by the Consultant.

2.7 Underbrush clearing

.1 Clear underbrush from areas as indicated at ground level.

2.8 Grubbing

.1 Remove and dispose of roots larger than 7.5 cm in diameter, matted roots, and designated stumps from indicated grubbing areas.

.2 Grub out stumps and roots to not less than 200 mm below ground surface.

.3 Grub out visible rock fragments and boulders, greater than 300 mm in greatest dimension, but less than 0.25 m^3.

.4 Pile uncovered rocks larger than 1,000 mm in diameter for landscape use as directed by the Consultant. If rocks are not required dispose of material off site.

.5 Fill depressions made by grubbing with suitable material and to make new surface conform with existing adjacent surface of ground.

2.9 Removal and disposal

.1 Remove cleared and grubbed materials off site or as otherwise indicated on drawings.

.2 Burial of materials is only permitted at the direction of the Consultant, by:

.1 Consolidating.

.2 Covering with minimum 600 mm of soil.

.3 Finishing the surface.

.3 Chipping and mulching of cleared and grubbed material on site is only permitted at the direction of the Consultant.

.4 Retain and stockpile stumps and rocks as directed by Consultant for reuse in construction of hibernacula or other wildlife habitat.

.5 Remove diseased trees identified by Consultant and dispose of this material off site.

2.10 Herbicide application

.1 Apply approved herbicide to stumps of invasive species that could not be removed by hand, according to manufacturer's instructions.

2.11 Finished surface

.1 Leave ground surface in condition suitable for stripping of topsoil.

2.12 Cleaning

.1 Proceed according to Section 01 74 19 – Cleaning and Waste Management.

.2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for rough grading in accordance with OPSS.MUNI 206 and as amended by this section.

1.2 Related sections

.1 Section 31 11 00 – Clearing and Grubbing

.2 Section 31 23 33 – Excavation, Trenching and Backfilling

1.3 References

.1 American Society for Testing and Materials (ASTM)

.1 Current ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (600 kN-m/m ;).

.2 Latest edition of Ontario Provincial Standard Specifications (OPSS):

.1 OPSS.MUNI 206 – Grading.

1.4 Submittals

.1 Submit in according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Existing conditions

.1 Examine subsurface investigation report if available.

.2 Verify underground and surface utility lines and buried objects are as indicated on site plan.

.3 Refer to dewatering in Section 31 23 33 - Excavating Trenching and Backfilling.

1.6 Protection

.1 Protect and/or transplant existing fencing trees, landscaping, natural features, bench marks, buildings, pavement, surface or underground utility lines which are to remain as indicated on the drawings. If damaged, restore to original or better condition unless directed otherwise.

.2 Protect newly graded and filled areas from washouts and settlement caused by rain and water drainage. Correct any damage as necessary.

.3 Maintain access roads to prevent accumulation of construction related debris on roads.

.4 Place filter fabric over catch basins and manholes to prevent clogging with sediment during the rough and fine grading operations.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Fill material: Type according to Section 31 23 33 – Excavating, Trenching and Backfilling.

.2 Excavated or graded material existing on site may be suitable to use as fill for grading work as directed by the soils report if approved by Consultant.

.3 Silt fence according to Section 31 23 33 – Excavating, Trenching and Backfilling.

3 Execution

3.1 Acceptance of site surface conditions

.1 Contract Drawings have been prepared with the intent to balance cut and fill though a balance is not guaranteed.

.2 The Contractor must make careful examination of existing and proposed site surface conditions and topography and advise the Consultant of any

unsatisfactory conditions, including any cut and fill discrepancies, prior to the commencement of construction.

.3 Commencement of construction will mean that the Contractor has accepted the existing and proposed site surface conditions and topography. No allowance will be made later for any expenses incurred through failure to note unsatisfactory site surface conditions or discrepancies in cut and fill balances.

3.2 Stripping of topsoil

.1 Do not handle topsoil while in wet or frozen condition or in any manner in which soil structure is adversely affected as determined by Consultant.

.2 Commence topsoil stripping of areas as indicated on drawings after area has been cleared and temporary silt protection fencing has been properly installed.

.3 Strip topsoil to depths as indicated on the drawings. Rototill weeds and grasses and retain as topsoil on site as approved by the Consultant. Avoid mixing topsoil with subsoil.

.4 Stockpile in locations as indicated on the drawings. Stockpile height not to exceed 2 m.

.5 Dispose of unused topsoil off site.

3.3 Rough grading

.1 Rough grade to levels, profiles, and contours allowing for surface treatment as indicated on drawings.

.2 Rough grade to specific depths below finish grades as per applicable details.

.3 Place fill in maximum 250 mm lifts.

.4 Slope rough grade away from buildings.

.5 Grade slopes for landscape areas to a maximum of 4:1 unless otherwise specified on the drawings.

.6 Grade ditches and swales to depths indicated on the drawings. Ensure gradient transitions are smooth and drain in the direction indicated.

.7 Prior to placing fill over existing ground, scarify surface to depth of 150 mm. Maintain fill and existing surface at approximately same moisture content to facilitate bonding.

.8 Compact filled and disturbed areas to maximum dry density to ASTM D698, as follows:

.1 85 % under landscaped areas.

.2 95 % under paved and walk areas.

.3 98 % under vehicular areas as per ASTM D1557.

.9 Do not disturb soil within branch spread of trees or shrubs to remain.

.10 Finished sub-grade surface to be free of debris or stones larger than 50 mm in diameter.

.11 Remove surplus material and material unsuitable for fill, grading or landscaping off site at Contractor's expense.

3.4 Testing

.1 Inspection and testing of soil compaction will be carried out by the Owner's appointed testing agency according to Section 01 45 00 – Quality Control.

.2 Costs of successful tests will be paid by the Owner.

.3 Costs for retesting due to failed tests will be paid by the Contractor.

End of section

1 General

1.1 Section includes

.1 Provide labour, materials, equipment and incidental services necessary to excavating, trenching, backfill and compaction in accordance with OPSS.MUNI 401 as amended by this section.

1.2 Related requirements

.1 Section 03 30 00 – Cast-in-Place Concrete

.2 Section 31 05 16 – Aggregates for Earthworks

.3 Section 31 22 13 – Rough Grading

.4 Section 32 91 19.13 – Topsoil Placement and Grading

1.3 References

.1 Latest version of Ontario Provincial Standard Specifications (OPSS)

.1 OPSS.MUNI 401 - Construction Specification for Trenching, Backfilling, and Compacting.

.2 OPSS.MUNI 1004 - Material Specification for Aggregates - Miscellaneous

.3 OPSS.MUNI 1010 - Material Specification for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material.

1.4 Submittals for information

.1 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.2 Product Data: For foundation drainage piping and accessories, and for protection sheets.

.3 Material Test Reports: For each on-site and imported soil material proposed for fill and backfill as follows:

.1 Classification according to ASTM D2487.

.2 Laboratory compaction curve according to ASTM D1557.

.4 Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by excavating and backfilling operations. Submit before earth moving begins.

.5 Qualifications Data: Installer.

1.5 Quality assurance

.1 Installer Qualifications: Company specializing in performing the work of this section with minimum five years continuous documented experience on projects of similar scope and size.

1.6 Regulatory requirements

.1 Excavation must be carried out according to the Occupational Health and Safety Act and Regulations for Construction Projects

.2 Perform excavation work to according to local authorities having jurisdiction.

.3 Perform work according to Ministry of Environment and Municipal regulations for removal and disposal of excavated materials off site. Apply, pay for and obtain permits, pay fees and submit declarations associated with disposal of excavated materials.

1.7 Site conditions

.1 Location of Existing Buried Utilities

.1 Existing utilities and structures indicated on the drawings are schematic only. Actual size, depth, and location must be determined by site locates and test excavation.

.2 Prior to commencing any excavation work, notify applicable authorities, and establish location and status of use of buried utilities and structures. Engage authorities having jurisdiction to clearly mark such locations to prevent disturbance during work.

.3 Confirm locations of buried utilities by careful test excavations.

.4 Conduct, with Consultant, condition survey of existing buildings, trees and other plants, lawns, fencing, service poles, wires, pavement, survey bench marks and monuments which may be affected by work.

1.8 Geotechnical site investigation report

.1 Review in detail geotechnical site investigation report, refer to Document Titled, *"Regional Municipality of Durham, Preliminary Geotechnical Investigation Proposed Pickering Emergency Medical Services (EMS) Facility, Northwest Corner of Concession Road 5 and Sideline 16, Pickering, Ontario, EXP November 2018".*

Information given in Geotechnical Site Investigation Report was obtained for use of Owner in execution of design. It is presented in good faith to assist Contractor. No guarantee is made as to its detailed accuracy.

1.9 Storage, delivery, handling and protection

.1 Stockpile materials in designated areas. Stockpile topsoil and each type of fill material separately to prevent integration. Stockpile granular materials so as to prevent segregation.

.2 Keep surrounding roads free of soil deposits from material hauling trucks. Load trucks carefully to prevent spillage and wind drift.

.3 To protect neighbourhood from wind-blown sand and dust, sprinkle with water entire excavated area and stockpiled excavated materials when required.

.4 Protect adjacent property from damage which may occur from any cause in the performance of the work of this Section.

.5 Do not interfere with use of adjacent buildings.

.6 Take precautions against movement, settlement or collapse of sidewalks, public services adjoining property and be liable for all damage to same.

.7 Before commencing work verify location of survey monuments in the areas in which the work is to be executed. Should any of the monuments be disturbed due to the work be responsible for the expenditures incurred in restoring the monuments.

.8 Take precautions against movement or settlement of existing building. Provide and place bracing and shoring necessary for the safety and

support of the structure and execute the work in a manner to prevent movement, settlement, damage or injury caused thereby or resulting therefrom.

.9 Shoring and Trench Timbering:

.1 In addition to requirements of local authorities, carry out according to requirements of the Occupational Health and Safety Act, RSO 1990 C.0.1 and regulations for construction projects, and all other applicable regulations of the Ontario Ministry of Labour. In addition, follow recommendations of the Construction Safety Association brochure, "Shoring and Timbering in Trenches, latest edition", wherever applicable.

.10 Shoring and Bracing:

.1 Erect and maintain necessary shoring and bracing for excavations in a manner that will properly retain banks of excavations and prevent cave-in. Shoring to be erected in a manner that will allow all other work to be carried out while shoring is still in place. Install shoring entirely clear of footings, foundations, walls or other such work so that it may be removed entirely or in sections when it is no longer required or when directed without causing any damage or injury to structural work that has been completed.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Fill material

.1 Type 1: Granular A, to OPSS.MUNI 1010.

.2 Type 2: Granular B, Type 1, (Engineered Fill), to OPSS.MUNI 1010.

.3 Type 3: selected native material from excavation, having moisture content within 3 % of optimum value, approved by Consultant for use intended, unfrozen, free from roots, rocks larger than 75 mm cinders, ashes, sods, refuse, or other deleterious materials.

.4 Type 4: clean, coarse concrete sand to CSA A23.1, free from clay, shale, and organic matter.

.5 Type 5: 20 mm, clear crushed stone, to CSA A23.1 (rounded aggregate will not be acceptable).

2.3 Accessories

.1 Protection Sheets: Filter fabric, water-permeable woven fabric of polypropylene or polyolefin, type acceptable to Consultant.

.1 '270R' by Terrafix Geosynthetics Inc, or approved alternate.

3 Execution

3.1 Examination

.1 Verify existing conditions before starting work.

.2 Do not commence excavating and backfilling operations until temporary erosion and sedimentation control measures are in place.

.3 Do not commence excavating and backfilling operations until preceding surface or layer is approved by geotechnical consultant.

.4 Excavating:

.1 Verify that survey bench mark and intended elevations for the Work are as indicated.

.5 Backfilling:

.1 Verify subdrainage and work to foundation walls has been inspected.

.2 Verify underground tanks are anchored to their own foundations to avoid flotation after backfilling.

.3 Verify structural ability of unsupported walls to support imposed loads by the fill.

3.2 Protection

.1 Provide acceptable temporary protection to structures, utilities, sidewalks, pavements, adjacent natural growth, landscaping, and other facilities from

damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavating and backfilling operations.

.2 Existing buried utilities and structures:

.1 Maintain and protect from damage, water, sewer, gas, electric, telephone and other utilities and structures encountered as indicated.

.2 Where utility lines or structures exist in area of excavation, obtain direction of Consultant before removing or re-routing. Pay costs of such work.

.3 Record location of maintained, re-routed and abandoned underground lines.

.3 Existing buildings and surface features:

.1 Protect existing buildings and surface features which may be affected by work from damage while work is in progress. In event of damage, immediately make repair to approval of Consultant.

.2 Where excavation necessitates root or branch cutting, do so only as approved by Consultant.

.4 Excavations

.1 Protect bottoms of excavations from softening or freezing.

.2 Construct banks according to local bylaws.

.3 Provide adequate protection around bench markers, layout markers, survey markers, and geodetic monuments.

.4 Effect approved measures to minimize dust as result of this work.

.5 Do not stockpile excavated material to interfere with site operation or drainage.

3.3 Shoring and bracing

.1 Protect excavations to provide safe working conditions, prevent cave-ins and falling loose soil, by shoring, bracing, sheet piling, under pinning or method acceptable Geotechnical Consultant. Design and install protection according to requirements of the Occupational Health and Safety Act and the authority having jurisdiction.

.2 Underpin adjacent buildings, structures, utilities damaged by excavation work.

.3 Remove shoring as backfilling operations progress.

3.4 Temporary erosion and sedimentation control

.1 Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction.

.2 Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross tree or plant protection zones.

.3 Inspect, maintain, and repair erosion and sedimentation control measures during construction until permanent vegetation has been established.

.4 Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.5 De-watering and heave prevention

.1 Keep excavations free of water while work is in progress.

.2 Submit, for Consultant's review, details of proposed dewatering or heave prevention methods, such as dikes, well points, and sheet pile cut-offs.

.3 Avoid excavation below groundwater table if quick condition or heave is likely to occur. Prevent piping or bottom heave of excavations by groundwater lowering, sheet pile cut-offs, or other means.

.4 Protect open excavations against flooding and damage due to surface run-off.

.5 Dispose of water in a manner not detrimental to public and private property, or any portion of work completed or under construction.

.6 Provide flocculation tanks, settling basins, or other treatment facilities to remove suspended solids or other materials before discharging to storm sewers, water courses or drainage areas.

3.6 Preparation

.1 Lines and Levels:

.1 Establish property lines, bench marks, main lines, levels and grid lines for the Project. Establish, provide, maintain and protect survey markers and geodetic monuments.

.2 Provide, verify, maintain and protect lines, layouts and grades required for excavating and backfilling work.

.2 Excavating: Notify utility company to remove and relocate utilities.

.3 Backfilling: according to OPSS 401 specifications.

.1 Compact subgrade to density requirements for subsequent backfill materials.

.2 Cut out soft areas of subgrade not capable of compaction in place. Backfill with structural fill and compact to density equal to or greater than requirements for subsequent fill material.

.3 Scarify and proof roll subgrade surface to a depth of 150 mm to identify soft spots and facilitate bonding of subsequent materials; fill and compact to density equal to or greater than requirements for subsequent fill material.

.4 Do not commence backfilling until work on foundation walls, drainage and other utilities have been installed, tested and approved.

3.7 Excavating

.1 Excavate subsoil to accommodate building foundations, slabs-on-grade, paving and other items specified or indicated.

.2 Limit damage to existing grade levels to greatest extent possible.

.3 Excavate to lines, grades, elevations, dimensions required with sufficient space to permit erection of formwork, shoring, and installation of materials, piping and similar items. Contour subgrade to provide drainage from entire excavated area if possible.

.4 Extend footings on grade to an elevation capable of sustaining imposed loads of bearing capacity indicated on the Structural Drawings; to a minimum of 1,400 mm below final exterior grade, for frost protection,

unless otherwise indicated; or unless otherwise to a depth directed by Geotechnical Consultant.

.5 Excavate to bearing depths required without interfering with 45 ° bearing splay of foundations.

.6 Unless otherwise directed by Geotechnical Consultant, limit permanent cut and fill slopes to a slope ratio of one (1) horizontal to one (1) vertical. Use flatter slopes for permanent slopes containing organic or silty soils.

.7 Subject to requirements of authorities having jurisdiction, provide the following minimum clear working spaces on each side of formwork, unless otherwise pre-approved by the Consultant.

.1 150 mm for footings under 300 mm in height.

.2 300 mm for walls under 900 mm in height.

.3 600 mm for walls over 900 mm in height.

.8 Trench Excavation: Excavate trenches only as far in advance of pipe laying operations and as safety, traffic and weather conditions permit, and in no case exceeding 30 m. Prior to stopping work on last day of work week, backfill trenches completely; protect trenches and excavations that cannot be backfilled with approved fencing or barricades and flashing lights.

.9 Grade top perimeter of excavations to prevent surface water from draining into excavation.

.10 Hand trim excavations free of loose materials and debris.

.11 Remove lumped subsoil, boulders, and rock up to 0.25 m^3.

.12 Remove all existing tree roots and stumps.

.13 Do not disturb soil within branch spread of trees or shrubs designated to remain. Excavating through roots by hand. Cut roots using a sharp axe or saw.

.14 Notify Consultant of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.

.15 Correct areas over excavated areas with fill material and compaction acceptable to Geotechnical Consultant.

.16 Compact disturbed load bearing soil in direct contact with foundations to original bearing capacity.

.17 Where required due to unauthorized over-excavation, correct as follows:

.1 Fill under bearing surfaces and footings with concrete specified for footings.

.2 Fill under other areas with Type 2 fill, compacted to not less than 100 % Standard Proctor Maximum Dry Density (SPMDD).

3.8 Disposal off site

.1 Dispose of existing fill and till not suitable for backfilling and compaction and as required to accommodate final site configuration; building foundations, slabs-on-grade, paving and other items specified or indicated.

3.9 Proof rolling

.1 Proof roll subgrade soils with a heavy roller; allow for two (2) passes in perpendicular directions for a total of a minimum of four (4) passes.

.2 Geotechnical Consultant will review results; proof roll for the Consultant review.

.3 Soft areas detected/identified by the Geotechnical Consultant will be replaced by approved material compacted to 100 % standard Proctor maximum dry density.

3.10 Backfilling

.1 Backfilling operations: According to OPSS 401 specifications.

.2 Do not proceed with backfill operations until Consultant has inspected and approved installations.

.3 Areas to be backfilled to be free from debris, snow, ice, water and frozen ground.

.4 Do not use backfill material which is frozen or contains ice, snow or debris.

.5 Prior to placing fill under slabs on grade, compact existing subgrade to obtain same compaction as specified for fill. Remove "soft" material and fill with approved material.

.6 Prior to installation of foundations, compact existing subgrade to obtain required bearing capacity. Remove "soft" material and fill footing concrete.

.7 Place backfill material in uniform layers not exceeding 152 mm compacted thickness up to grades indicated. Compact each layer before placing succeeding layer.

.8 Backfill around services:

.1 Place bedding and surround material as specified in fill and compaction schedule.

.2 Do not backfill around or over cast-in-place concrete within twenty four (24) hours after placing of concrete.

.3 Place layers simultaneously on both sides of installed work to equalize loading.

.4 Where temporary unbalanced earth pressures are liable to develop on walls or other structures:

.1 Permit concrete to cure for minimum fourteen (14) days or until it has sufficient strength to withstand earth and compaction pressure, and approval is obtained from Consultant.

.2 If approved by Consultant, erect bracing or shoring to counteract unbalance, and leave in place until removal is approved by Consultant.

.5 Place material by hand under, around and over installations until 600mm of cover is provided. Dumping material directly on installations will not be permitted.

3.11 Site quality control

.1 Testing of materials and compaction will be carried out by testing laboratory designated by the Consultant.

.2 Frequency of Tests

.1 Excavated surfaces: when undisturbed excavated surface is being prepared, make a series of three (3) tests of surface for each 500 m^2 area.

.2 Fill under floor or other slabs on grade: make three (3) tests for every two (2) lifts of compacted fill for each 500 m^2 area.

.3 Backfill structural walls: test each different material for approximately each 50 m of wall being backfilled, at depth increments of 600 mm.

.4 If, during progress of work, tests indicate fills do not meet specified requirements, remove defective fills, replace and retest at no extra cost.

3.12 Protection of finished work

.1 Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

.2 Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

.1 Scarify or remove and replace soil material to depth as directed by Consultant; reshape and recompact.

3.13 Fill and compaction schedule

.1 Exterior side of perimeter foundation walls: Type 2 fill to subgrade level. Compact to 95 % SPMDD according to ASTM D698.

.2 Under asphalt and concrete paving: Type 2 fill to underside of base course. Compact to 98 % SPMDD according to ASTM D698.

.3 Sub-Base Courses for concrete slabs-on-grade

.1 Engineered Fill: Type 2 fill to underside of base course for floor slabs. Compact to 100 % SPMDD according to ASTM D698. Refer to Structural Drawings for location and depth.

.2 Other sub-base within building area: Type 2 to underside of base course for floor slabs. Compact to 98 % SPMDD.

.4 Base Course for concrete slabs-on-grade

.1 Within building area: 152 mm Type 1 fill provided by Section 03 30 00 – Cast-in-Place Concrete. Compact to 100 % SPMDD.

.2 Exterior concrete paving: 152 mm Type 1 fill provided by Section 03 30 00 – Cast-in-Place Concrete. Compact to 98 % SPMDD.

.3 Moisture Barrier: provide 200 mm type 5 clear crushed stone directly below slab on grade vapor barrier.

.5 Landscape Retaining walls: provide 152 mm Type 1 fill below retaining wall, compact to 100 % SPMDD. Provide Type 5 fill to subgrade level on high side for minimum 300 mm from wall, well compacted. For remainder, use Type 3 fill compacted to 95 % SPMDD.

.6 Underground services:

.1 Sanitary and storm sewer pipe, water pipe, and conduit protective cover: cradle half diameter of pipe or conduit using 150 mm depth of Type 4 fill. After pipe or conduit is in place, cover with 300 mm depth of Type 1 fill.

.2 Cable and cable duct bedding and immediate protective cover: cover bottom of trench with 150 mm of Type 4 fill. After cables and ducts are in place, side fill ducts with sand up to top of ducts. Tamp around ducts with hand tampers and cover with 150 mm of same material.

.3 Fill above protective cover: in areas within buildings and where paving and walks occur, fill remainder of trench with Type 2 fill. In other areas, fill to subgrade level using Type 3 fill.

.4 Compaction: compact bedding and immediate protective cover to 100 % SPMDD. In areas within buildings and where paving and walks occur, compact remainder of fill to at least 100 % SPMDD. In other areas compact remainder of fill to 95 % SPMDD.

.5 Notify Consultant three (3) days prior to backfilling of trenches for electrical services.

End of section

1 General

1.1 Section includes

.1 Materials and installation of polymeric geotextiles in accordance with OPSS.MUNI 1860 and amended by this section used in revetments, breakwaters, retaining wall structures, filtration, drainage structures, roadbeds s purpose of which is to:

.1 Separate and prevent mixing of granular materials of different grading.

.2 Act as hydraulic filters permitting passage of water while retaining soil strength of granular structure.

1.2 Related sections

.1 Section 31 22 13 – Rough Grading

.2 Section 31 23 33 – Excavating, Trenching and Backfilling

.3 Section 32 91 19.13 – Topsoil Placement and Grading

1.3 References

.1 American Society for Testing and Materials International, (ASTM)

.1 Current ASTM D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

.2 Current ASTM D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.

.3 Current ASTM D4716, Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.

.4 Current ASTM D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.

.2 Canadian General Standards Board (CGSB)

.1 Current CAN/CGSB-4.2, Textile Test Methods - Bursting Strength - Ball Burst Test (Extension of September 1989).

.2 Current CAN/CGSB-148.1, Methods of Testing Geotextiles and Complete Geomembranes.

.1 No.2, Methods of Testing Geosynthetics - Mass per Unit Area.

.2 No.3, Methods of Testing Geosynthetics - Thickness of Geotextiles.

.3 No.6.1, Methods of Testing Geotextiles and Geomembranes - Bursting Strength of Geotextiles Under No Compressive Load.

.4 No.7.3, Methods of Testing Geotextiles and Geomembranes - Grab Tensile Test for Geotextiles.

.5 No. 10, Methods of Testing Geosynthetics - Geotextiles - Filtration Opening Size.

.3 Canadian Standards Association (CSA International)

.1 Current CAN/CSA-G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel.

.2 Current CAN/CSA-G164, Hot Dip Galvanizing of Irregularly Shaped Articles.

.4 Ontario Provincial Standard Specifications (OPSS)

.1 Current OPSS.MUNI 1860, Material Specification for Geotextiles.

1.4 Submittals

.1 Submit samples according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Submit a 1 m length sample from full roll width of geotextile material to Consultant for approval prior to installation.

.4 Indicate manufacturer and source of geotextile material.

1.5 Delivery, storage and handling

.1 During delivery and storage, protect geotextiles from direct sunlight, ultraviolet rays, excessive heat, mud, dirt, dust, debris and rodents.

1.6 Waste management and disposal

.1 Separate waste materials for reuse and recycling according to Section 01 74 19 – Construction and Demolition Waste Management.

.2 Remove from site and dispose of all packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material for recycling according to Waste Management Plan.

.4 Fold up metal banding, flatten and place in designated area for recycling.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Material

.1 Provide geotextiles according to OPSS.MUNI 1860 and the following:

.1 Shrub beds and drip strip: Terrafix 240R (or approved alternate).

.2 Geotextile: woven or non-woven synthetic fibre fabric, supplied in rolls.

.3 Generic specifications including physical properties, roll width, roll length, thickness, tensile strength, mass, bursting strength and hydraulic properties as per approved manufacturer’s specifications.

.4 Securing pins and washers or seams: according to manufacturer’s recommendations.

.5 Thread for sewn seams: equal or better resistance to chemical and biological degradation than geotextile.

3 Execution

3.1 Installation

.1 Place geotextile material by unrolling onto graded surface in orientation, manner and locations indicated.

.2 Place geotextile material smooth and free of tension stress, folds, wrinkles and creases.

.3 Place geotextile material on sloping surfaces in one continuous length from toe of slope to upper extent of geotextile.

.4 Overlap each successive strip of geotextile 450 mm over previously laid strip.

.5 Join successive strips of geotextile as recommended by approved manufacturer.

.6 Protect installed geotextile material from displacement, damage or deterioration before, during and after placement of material layers.

.7 After installation, cover with overlying layer within four (4) h of placement.

.8 Replace damaged or deteriorated geotextile to approval of Consultant.

3.2 Cleaning

.1 Remove construction debris from Project site and dispose of debris in an environmentally responsible and legal manner.

3.3 Protection

.1 Vehicular traffic not permitted directly on geotextile.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for Rip-Rap in accordance with OPSS.MUNI 511 and as amended by this section.

1.2 Related sections

.1 Section 31 22 13 – Rough Grading

.2 Section 31 32 19.01 – Geotextiles

1.3 References

.1 Latest edition of Ontario Provincial Standard Specifications (OPSS):

.1 OPSS.MUNI 511 - Rip-Rap, Rock Protection and Granular Sheeting.

1.4 Submittals

.1 Submit in according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Waste management and disposal

.1 Separate and recycle waste materials according to Section 01 74 19 – Construction and Demolition Waste Management.

.2 Collect and separate plastic, paper packaging and corrugated cardboard according to Waste Management Plan.

.3 Place materials defined as hazardous or toxic in designated containers.

.4 Fold up metal banding, flatten and place in designated area for recycling.

.5 Divert left over aggregate materials from landfill to local facility for reuse as approved by Consultant.

.6 Divert left over hardened cement materials from landfill to local facility for reuse as approved by Consultant.

.7 Divert left over geotextiles to local plastic recycling program as approved by Consultant.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Stone

.1 Hard, rounded, washed, dense, durable river stone, free from seams, cracks or other structural defects, to meet following size distribution for use intended:

.1 Hand placed rip-rap:

.1 Minimum size of individual stones to equal 100 mm in diameter.

.2 Maximum size of individual stones to equal 150 mm in diameter.

.3 Supply rock spalls or cobbles to fill open joints.

2.3 Cement mortar

.1 Not used.

2.4 Geotextile filter

.1 Geotextile: according to Section 31 32 19.01 – Geotextiles.

3 Execution

3.1 Placing

.1 If rip-rap is to be placed on slopes, excavate trench at toe of slope to dimensions as indicated.

.2 Fine grade area to be rip-rapped to uniform, even surface. Fill depressions with suitable material and compact to provide firm bed.

.3 Place geotextile on prepared surface according to Section 31 32 19.01 – Geotextiles and as indicated. Avoid puncturing geotextile. Vehicular traffic over geotextile not permitted.

.4 Place rip-rap to thickness and details as indicated.

.5 Place stones in manner approved by Consultant to secure surface and create a stable mass. Place larger stones at bottom of slopes.

.6 Hand placing:

.1 Use larger stones for lower courses and as headers for subsequent courses.

.2 Stagger vertical joints and fill voids with rock spalls or cobbles.

.3 Finish surface evenly, free of large openings and neat in appearance.

.7 Mortar:

.1 Not used.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for granular sub-base in accordance with OPSS.MUNI 314 and as amended by this section.

1.2 Related sections

.1 Section 03 30 00 – Cast-in-Place Concrete

.2 Section 10 75 00 – Flagpoles

.3 Section 32 14 10 – Unit Paving

.4 Section 32 16 15 – Concrete Walks, Curbs and Gutters

1.3 References

.1 American Society for Testing and Materials (ASTM)

.1 Current ASTM C117, Standard Test Methods for Material Finer Than 0.075 mm Sieve in Mineral Aggregates by Washing.

.2 Current ASTM C131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

.3 Current ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.4 Current ASTM D422, Standard Test Method for Particle-Size Analysis of Soils.

.5 Current ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft^3) (600kN-m/m^3).

.6 Current ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000ft-lbf/ft^3) (2,700kN-m/m^3).

.7 Current ASTM D1883, Standard Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.

.8 Current ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

.2 Canadian General Standards Board (CGSB)

.1 Current CAN/CGSB-8.1, Sieves, Testing, Woven Wire, Inch Series.

.2 Current CAN/CGSB-8.2, Sieves, Testing, Woven Wire, Metric.

.3 Latest edition of Ontario Provincial Standard Specifications (OPSS):

.1 OPSS.MUNI 314, Untreated Granular Subbase, Base, Surface, Shoulder, and Stockpiling.

.2 OPSS.MUNI 1010, Aggregates - Base, Subbase Select Subgrade, and Backfill Material.

1.4 Waste management and disposal

.1 Separate and recycle waste materials according to Section 01 74 19 – Construction and Demolition Waste Management .

.2 Divert unused granular material from landfill to local facility as approved by Consultant.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Granular sub-base material: according to the following requirements:

.1 Crushed, pit run or screened stone, gravel or sand free from clay lumps, cementation, organic material, frozen material and other deleterious materials.

.2 Gradations to be within limits and requirements specified for Granular A and Granular B (Type 1 and 2), Ontario Provincial Standard Specifications OPSS.MUNI 1010.

3 Execution

3.1 Placing

.1 Place granular sub-base after subgrade is inspected and approved by Consultant.

.2 Construct granular sub-base to depth and grade in areas indicated.

.3 Ensure no frozen material is placed.

.4 Place material only on clean unfrozen surface, free from snow or ice.

.5 Begin spreading sub-base material on crown line or high side of one-way slope.

.6 Place granular sub-base materials using methods which do not lead to segregation or degradation.

.7 For spreading and shaping material, use spreader boxes having adjustable templates or screeds which will place material in uniform layers of required thickness.

.8 Place material to full width in uniform layers not exceeding 150 mm compacted thickness. Consultant may authorize thicker lifts (layers) if specified compaction can be achieved.

.9 Shape each layer to smooth contour and compact to specified density before succeeding layer is placed.

.10 Remove and replace portion of layer in which material has become segregated during spreading.

3.2 Compaction

.1 Compaction equipment to be capable of obtaining required material densities.

.2 Compact to density of not less than 98 % maximum dry density according to ASTM D698.

.3 Shape and roll alternately to obtain smooth, even and uniformly compacted sub-base.

.4 Apply water as necessary during compaction to obtain specified density.

.5 In areas not accessible to rolling equipment, compact to specified density with mechanical tampers approved by Consultant.

.6 Correct surface irregularities by loosening and adding or removing material until surface is within specified tolerance.

3.3 Proof rolling

.1 For proof rolling use standard roller of 45,400 kg gross mass with four pneumatic tires each carrying 11,350 kg and inflated to 620 kPa. Four tires arranged abreast with centre to centre spacing of 730 mm maximum.

.2 Obtain approval from Consultant to use non standard proof rolling equipment.

.3 Proof roll at level in sub-base as indicated. If non standard proof rolling equipment is approved, Consultant to determine level of proof rolling.

.4 Make sufficient passes with proof roller to subject every point on surface to three separate passes of loaded tire.

.5 Where proof rolling reveals areas of defective subgrade:

.1 Remove sub-base and subgrade material to depth and extent as directed by Consultant.

.2 Backfill excavated subgrade with material and compact according to Section 331 23 33 – Excavating, Trenching and Backfilling.

.3 Replace sub-base material and compact.

.6 Where proof rolling reveals areas of defective sub-base, remove and replace according to this section at no additional cost to the Owner.

3.4 Site tolerances

.1 Finished sub-base surface to be within 10 mm of elevation as indicated but not uniformly high or low.

3.5 Protection

.1 Maintain finished sub-base in condition according to this section until succeeding base is constructed, or until granular sub-base is accepted by Consultant.

End of section

1 General

1.1 Section includes

.1 This section includes the materials and installation for roadway granular base and sub-base as well as granular base materials for sidewalk and pathway pavement structures in accordance with OPSS.MUNI 314 and as amended by this section.

1.2 Related requirements

.1 Section 31 05 16 – Aggregate for Earthworks

.2 Section 31 23 33 – Excavating, Trenching and Backfilling

.3 Section 32 12 16 – Asphalt Paving

1.3 Reference standards

.1 ASTM International

.1 ASTM C117, Standard Test Methods for Material Finer Than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing.

.2 ASTM C131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

.3 ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.4 ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft. lbf/ft^3) (600 kN-m/m^3).

.5 ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft. lbf/ft^3) (2,700 kN-m/m^3).

.6 ASTM D1883, Standard Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.

.7 ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

.2 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-8.2-M, Sieves, Testing, Woven Wire, Metric.

.3 Latest edition of Ontario Provincial Standard Specifications (OPSS) and local municipalities standards and specifications not listed below:

.1 OPSS.MUNI 314 Construction Specification for Untreated Granular, Subbase, Base, Surface Shoulder and Stockpiling.

.2 OPSS.MUNI 501 Construction Specification for Compacting.

.3 OPSS.MUNI 1001 Material Specification for Aggregates - General.

.4 OPSS.MUNI 1010 Material Specification for Aggregates - Base, Subbase, Select Subgrade, and Backfill Material.

.4 Ministry of Transportation (MTO)

.1 LS-602 (latest edition) - Sieve Analysis for Aggregates.

1.4 Submittals

.1 Submit according to Sections 01 33 00 – Submittal Procedures and 31 05 16 – Aggregate for Earthworks.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Quality assurance

.1 Testing Agency: Owner will retain a Professional Engineer, registered in the Province of the work, to provide testing and inspection services for the work of this Section according to applicable codes, standards and Contract Documents.

.2 Certifications:

.1 Submit confirmation by the Testing Agency that materials and installation complies with the Contract Documents.

.3 Test Data:

.1 If requested by Consultant, submit test data verifying that specified requirements are being met. Test results may be from a previous

testing program conducted on a system similar to that specified herein.

.4 Provide access for the Testing Agency to complete independent testing and for sampling.

.5 Comply with Section 31 05 16 – Aggregates for Earthworks.

1.6 Delivery, storage and handling

.1 Deliver, store and handle materials according to Section 01 65 00 – Product Delivery Requirements.

1.7 Waste management and disposal

.1 Waste Management: separate waste materials for reuse, recycling according to Section 01 74 00 – Cleaning and Waste Management.

.1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

.2 Divert unused granular material from landfill to local facility approved by Testing Agency.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Granular base: material according to OPSS.MUNI 1010 Granular A:

.1 Crushed stone or gravel.

.2 Gradations to be within limits specified when tested to MTO LS-602. Sieve sizes to CAN/CGSB-8.1.

.3 Gradation Method to: MTO LS-602 for granular A.

.2 Granular subbase: material according to OPSS.MUNI 1010 Granular B Type I.

.1 Pit Run material

.2 Recycled / Reclaimed Concrete Material (RCM) will not be permitted.

.3 Gradation Method to: MTO LS-602 for granular B Type I.

.3 19 mm Crusher Run Limestone granular base: material according to OPSS.MUNI 1004Granular A:

.1 Crushed stone or gravel.

.2 Gradations to be within limits specified when tested to MTO LS-602. Sieve sizes to CAN/CGSB-8.1.

.3 Gradation Method to: MTO LS-602 for granular A.

3 Execution

3.1 Placement and installation

.1 Place granular base after sub-base surface is inspected and approved in writing by Testing Agency.

.2 Place granular sub-base after subgrade surface is inspected and approved in writing by Testing Agency.

.3 Placing:

.1 Construct granular base to depth and grade in areas indicated.

.2 Ensure no frozen material is placed.

.3 Place material only on clean unfrozen surface, free from snow and ice.

.4 Begin spreading base material on crown line or on high side of one-way slope.

.5 Place material using methods which do not lead to segregation or degradation of aggregate.

.6 For spreading and shaping material, use spreader boxes having adjustable templates or screeds which will place material in uniform layers of required thickness.

.7 Place material to full width in uniform layers not exceeding 150 mm compacted thickness.

.1 Testing Agency may authorize thicker lifts (layers) if specified compaction can be achieved.

.8 Shape each layer to smooth contour and compact to specified density before succeeding layer is placed.

.9 Remove and replace that portion of layer in which material becomes segregated during spreading.

.4 Compaction Equipment:

.1 Ensure compaction equipment is capable of obtaining required material densities.

.2 Efficiency of equipment not specified to be proved at least as efficient as specified equipment at no extra cost and written approval must be received from Testing Agency before use.

.3 Equipped with device that records hours of actual work, not motor running hours.

.5 Compacting:

.1 Compact to density not less than Min 98 % maximum dry density to ASTM D698.

.2 Shape and roll alternately to obtain smooth, even and uniformly compacted base.

.3 Apply water as necessary during compacting to obtain specified density.

.4 In areas not accessible to rolling equipment, compact to specified density with mechanical tampers approved in writing by Testing Agency.

.5 Correct surface irregularities by loosening and adding or removing material until surface is within specified tolerance.

.6 For proof rolling use standard roller of 45,400 kg gross mass with four pneumatic tires each carrying 11,350 kg and inflated to 620 kPa. Four tires arranged abreast with centre to centre spacing of 730 mm.

.7 Obtain written approval from Testing Agency to use non standard proof rolling equipment.

.8 Proof roll at level in granular base as indicated.

.1 If use of non standard proof rolling equipment is approved, Testing Agency to determine level of proof rolling.

.9 Make sufficient passes with proof roller to subject every point on surface to three separate passes of loaded tire.

.10 If proof rolling reveals areas of defective subgrade:

.1 Remove base, sub-base and subgrade material to depth and extent as directed by Testing Agency.

.2 Backfill excavated subgrade with sub-base material and compact.

.3 Replace base material and compact according to this Section.

.11 If proof rolling reveals defective base or sub-base, remove defective materials to depth and extent as directed by Testing Agency and replace with new materials at no extra cost.

3.2 Field quality control

.1 Minimum testing requirements for the Contractor to undertake:

.1 Proof-roll road sub-grade in the presence of the Testing Agency.

.2 Provide quality control for compaction of various materials according to OPSS 501 Table 1 with the following modifications:

.1 Part 1 (I) lot size to be every lift (max. 0.3 m) 30 m maximum length in a `Z' pattern.

.2 Minimum compaction requirement for granular base and subbase to 100 % MDD.

3.3 Site tolerances

.1 Finished base surface to be within plus or minus 10mm of established grade and cross section but not uniformly high or low.

3.4 Cleaning

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment.

3.5 Protection

.1 Maintain finished base in condition according to this Section until succeeding material is applied or until acceptance by the Testing Agency.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for asphalt paving.

1.2 Related requirements

.1 Section 32 11 23 – Aggregates Base Courses

1.3 Reference standards and reports

.1 Ontario Provincial Standard Specification OPSS.MUNI 1003 Nov 2013 "Material Specification for Aggregates – Hot Mixed Asphalt"

.2 Ontario Provincial Standard Specification OPSS.MUNI 310 Sept 2017 "Construction Specification for Hot Mixed, Hot Laid Asphaltic Concrete Paving"

.3 Ontario Provincial Standard Specification OPSS.PROV 308 Apr. 2012 "Construction Specification for Tack Coating and Joint Spacing"

.4 Ontario Provincial Standard Specification OPSS.MUNI 311 Nov 2018 "Construction Specification for Asphalt Sidewalks, Driveway, And Boulevard And For Sidewalk Resurfacing"

.5 Ontario Provincial Standard Specification OPSS.MUNI 1101 Nov 2016 "Material Specification for Performance Graded Asphalt Cement"

.6 Ontario Provincial Standard Specification OPSS.MUNI 1103 Nov 2019 "Material Specification for Emulsified Asphalt"

.7 Ontario Provincial Standard Specification OPSS.MUNI 1150 Nov 2020 "Material Specification for Hot Mix Asphalt"

.8 Ontario Provincial Standard Specification OPSS.MUNI 1151 Apr 2018 "Material Specification for Superpave and Stone Mastic Asphalt Mixtures"

.9 American Association of State Highway and Transportation Officials (AASHTO)

.1 AASHTO M320, Standard Specification for Performance Graded Asphalt Binder.

.2 AASHTO R29, Standard Specification for Grading or Verifying the Performance Graded of an Asphalt Binder.

.3 AASHTO T245, Standard Method of Test for Resistance to Plastic flow of Bituminous Mixtures Using Marshall Apparatus.

.10 Asphalt Institute (AI)

.1 AI MS-2 Sixth Edition, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types.

.11 ASTM International

.1 ASTM C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate.

.2 ASTM C117, Standard Test Method for Material Finer Than 0.075mm (No.200) Sieve in Mineral Aggregates by Washing.

.3 ASTM C123, Standard Test Method for Lightweight Particles in Aggregate.

.4 ASTM C127, Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate.

.5 ASTM C128, Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate.

.6 ASTM C131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

.7 ASTM C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

.8 ASTM C207, Standard Specification for Hydrated Lime for Masonry Purposes

.9 ASTM D995, Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.

.10 ASTM D2419, Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.

.11 ASTM D3203, Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures.

.12 ASTM D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

.12 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-8.1, Sieves Testing, Woven Wire, Inch Series.

.2 CAN/CGSB-8.2-M, Sieves Testing, Woven Wire, Metric.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for asphalt mixes and aggregate and include product characteristics, performance criteria, physical size, finish and limitations four (4) weeks prior to beginning Work.

.2 Submit viscosity-temperature chart for asphalt cement to be supplied showing either Saybolt Furol viscosity in seconds or Kinematic Viscosity in centistokes, temperature range 105 to 175 °C four (4) weeks prior to beginning Work.

.4 Samples:

.1 Inform Testing Agency of proposed source of aggregates and provide access for sampling four (4) weeks prior to beginning Work.

.2 Submit samples of following materials proposed for use four (4) weeks prior to beginning Work.

.1 One (1) 5 L container of asphalt cement.

.2 1 kg of hydrated lime.

.5 Test and Evaluation Reports:

.1 Submit manufacturer's test data and certification that asphalt cement meets specification requirements four (4) weeks prior to beginning Work.

.2 Submit manufacturer's test data and certification that hydrated lime meets specified requirements four (4) weeks prior to beginning Work.

.3 Submit asphalt concrete mix design and trial mix test results at least four (4) weeks prior to beginning Work.

.4 Submit printed record of mix temperatures at end of each day.

1.5 Quality assurance

.1 Materials must according to OPSS 1003, 1101 and 1150/1151.

.2 Testing Agency: A Professional Engineer, registered in the Province of the work, to provide testing and inspection services for the work of this Section according to applicable codes, standards and Contract Documents.

.3 Certifications:

.1 Submit confirmation by the Testing Agency that materials and installation complies with the Contract Documents.

.2 Testing agency to be present at mixing facility to certify reclaimed asphalt paving does not exceed 15 %.

.4 Test Data:

.1 If requested by Consultant, submit test data verifying that specified requirements are being met. Test results may be from a previous testing program conducted on a system similar to that specified herein.

1.6 Delivery, storage and handling

.1 Deliver, store and handle materials according to Section 01 65 00 – Product Delivery Requirements.

.2 Submit to Testing Agency copies of freight and waybills for asphalt cement as shipments are received.

.1 Testing Agency reserves right to check weights as material is received.

1.7 Waste management and disposal

.1 Waste Management: separate waste materials for recycling/reuse according to Section 01 74 00 – Cleaning and Waste Management.

.2 Remove recycling containers and bins from site and dispose of materials at appropriate facilities.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Asphalt base course: to meet Ontario Provincial Standard Specification OPSS.MUNI 1150 for type HL 8 PGAC 64-28. Maximum size aggregate 26.5 mm. Provide reclaimed asphalt pavement (RAP) up to maximum of 30% as per OPSS.MUNI 1150.

.2 Asphalt surface course: to meet Ontario Provincial Standard Specification OPSS.MUNI 1150 for type HL 3 PGAC 64-28. Maximum size aggregate 16 mm. Provide maximum 15% reclaimed asphalt pavement (RAP)as per OPSS.MUNI 1150.

3 Execution

3.1 Examination

.1 Check graded granular base for according to elevations and cross-sections before placing asphalt material.

.2 Aggregate base course to be in according to Section 32 11 23 – Aggregate Base Courses prior to paving.

.3 Proof-roll granular base surface with mass and type of roller approved by Testing Agency.

.4 Check for unstable areas.

.5 Check for areas requiring additional compaction.

.6 Notify Testing Agency of unsatisfactory conditions.

.7 Do not begin paving work until such conditions have been corrected and are ready to receive paving.

.8 When complete, have the Testing Agency inspect excavations to verify soil bearing capacities/subgrade conditions, depths and dimensions.

.9 Correct unauthorized excavation at no extra cost by filling and compacting with Granular 'A' material as per Section 32 11 23 – Aggregate Base Courses.

3.2 Joints

.1 Saw Cut existing bituminous course to full depth in straight or curved lines as required to expose fresh vertical surfaces. Remove any broken or loose material.

.2 Paint exposed edge of asphaltic joints, curbs and similar items with asphalt primer prior to placing asphalt courses.

.3 Where paving comprises two courses overlap longitudinal joints not less than 500 mm.

.4 Carefully place and compact hot asphaltic material against joints.

3.3 Installation

.1 Install vehicular asphalt base course and asphalt surface course according to the requirements of OPSS 310 and the Contract Drawings.

.2 Install pathway asphalt according to the requirements of OPSS 311 and the Contract Drawings.

.3 Construct all paving in straight lines along the shoulders.

3.4 Field quality control

.1 Minimum testing requirements of the Contractor to demonstrate quality control:

.1 Take samples every 150 m each lane and record temperature (identify chainage and left or right).

.2 Two (2) marshall tests and two (2) extraction tests per full day of paving.

.3 Test asphalt surfaces every 15 m each lane, all locations to be identified by chainage and offset.

.4 According to OPSS 1003, 1101 and 1150/1151.

.5 Minimum compaction to 92 % Marshall Relative Density.

3.5 Finish tolerances

.1 Finished asphalt surface to be within 5 mm of design elevation but not uniformly high or low.

.2 Finished asphalt surface not to have irregularities exceeding 5 mm when checked with 4.5 m straight edge placed in any direction.

3.6 Defective work

.1 Correct irregularities which develop before completion of rolling by loosening surface mix and removing or adding material as required.

.1 If irregularities or defects remain after final compaction, remove surface course promptly and lay new material to form true and even surface and compact immediately to specified density.

.2 Repair areas showing checking, rippling, or segregation.

.3 Adjust roller operation and screed settings on paver to prevent further defects such as rippling and checking of pavement.

3.7 Cleaning

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment

End of section

1 General

1.1 Section includes

.1 Materials and installation for sand-set unit paving without mortared joints, by hand or with mechanical equipment, for pedestrian or light vehicular traffic.

1.2 Related sections

.1 Section 01 33 00 – Submittal Procedures

.2 Section 01 45 00 – Quality Control

.3 Section 01 74 19 – Construction and Demolition Waste Management

.4 Section 03 30 00 – Cast-in-Place Concrete

.5 Section 31 32 19.01 – Geotextiles

.6 Section 32 11 16.01 – Granular Sub-base

.7 Section 32 16 15 – Concrete Walks, Curbs and Gutters

1.3 References

.1 American Society for Testing and Materials International, (ASTM).

.1 Current ASTM C117, Standard Test Method for Material Finer Than 75-mu m (No.200) Sieve in Mineral Aggregates by Washing.

.2 Current ASTM C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

.3 Current ASTM C902, Standard Specification for Pedestrian and Light Traffic Paving Brick.

.4 Current ASTM C979, Standard Specification for Pigments for Integrally Coloured Concrete.

.5 Current ASTM C1272, Standard Specification for Heavy Vehicular Paving Brick.

.6 Current ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3(600kN-m/m^3)).

.7 Current ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3(2,700kN-m/m^3)).

.8 Current ASTM E11, Standard Specification for Wire-Cloth Sieves for Testing Purposes.

.2 Canadian General Standards Board (CGSB).

.1 Current CAN/CGSB-8.1, Sieves, Testing, Woven Wire, Inch Series.

.2 Current CAN/CGSB-8.2, Sieves, Testing, Woven Wire, Metric.

.3 Canadian Standards Association (CSA International).

.1 Current CSA A23.1/A23.2, Concrete Materials and Methods of Construction/Methods of Test for Concrete.

.2 Current CSA A179, Mortar and Grout for Unit Masonry.

.3 Current CSA-A231.1, Precast Concrete Paving Slabs.

.4 Current CSA-A231.2, Precast Concrete Pavers.

.5 Current CSA-A283, Qualification Code for Testing Laboratories.

1.4 Submittals

.1 Submit following product test data:

.1 Sieve analysis for gradation of bedding and joint material.

.2 Unit paver test data.

.3 Evaluation of cleaning and sealing compound.

.2 Submit two (2) copies of WHMIS MSDS – Material Safety Data Sheets. Indicate VOCs:

.1 For cleaning and sealing compounds.

.3 Submit shop drawings, samples and product data according to Section 01 33 00 – Submittal Procedures.

.4 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.5 Indicate layout, pattern and relationship of paving joints to fixtures and project formed details.

.6 Submit full size sample of each type of paving unit.

.7 Manufacturer's Instructions:

.1 Submit manufacturer's installation instructions.

1.5 Quality assurance

.1 Qualifications:

.1 Installer: company or person specializing in precast concrete paver installations with five (5) years documented experience and approved by Consultant.

.2 Test Reports: certified test reports showing compliance with specified performance characteristics and physical properties.

.3 Certificates: product certificates signed by manufacturer certifying materials comply with specified performance characteristics and criteria and physical requirements.

.4 Mock-ups:

.1 Construct mock-up according to Section 01 45 00 – Quality Control.

.2 Install 3 x 1.5 m area mock-up.

.3 Mock-up will be used:

.1 To judge workmanship, substrate preparation, operation of equipment and material application.

.2 To determine surcharge of bedding layer, joint sizes, lines, laying pattern(s), colour(s) and texture.

.3 Locate where directed by Consultant.

.4 Allow twenty (24) hours for inspection of mock-up before proceeding with work.

.5 If accepted, mock-up will demonstrate minimum standard of quality required for this work. Approved mock-up may remain as part of finished work.

.5 Pre-Installation Meetings: conduct pre-installation meeting to verify project requirements, manufacturer's installation instructions and manufacturer's warranty requirements.

1.6 Waste management and disposal

.1 Separate waste materials for reuse and recycling according to Section 01 74 19 – Construction and Demolition Waste Management.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, and corrugated cardboard packaging material for recycling according to Waste Management Plan.

.4 Divert unused concrete materials from landfill to local facility as approved by Consultant.

.5 Divert unused aggregate materials from landfill to facility for reuse as approved by Consultant.

.6 Divert unused geotextiles from landfill to plastic recycling facility approved by Consultant.

.7 Fold up metal banding, flatten and place in designated area for recycling.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Unit pavers: uniform in material, colour, size and from one manufacturer.

.2 Precast concrete unit pavers: to CSA-A231.1.

.1 Type 1: Mattoni, 6 cm x 24 cm x 7 cm, dark charcoal, supplied by Unilock; or approved alternate.

.2 Pigment in concrete pavers: to ASTM C979.

.3 Crushed stone or gravel base: according to Section 32 11 16.01 – Granular Sub-base.

.4 Manufactured sand for bedding: hard, durable, crushed stone particles, according to gradation of concrete sand as specified in CAN/CSA A23.1. Sand: free from clay lumps, cementation, organic material, frozen material and other deleterious materials. Do not use limestone screenings or stone dust.

.1 Gradations: within limits specified if tested to ASTM C136 and ASTM C117.

Sieve Designation	% Passing
10 mm	100
5 mm	95-100
2.5 mm	80-100
1.25 mm	50- 90
0.630 mm	25- 60
0.315 mm	10- 35
0.160 mm	2- 10
0.075 mm	0

.5 Polymeric Joint Sand: fine sand conforming to CSA A23.1/A23.2 combined with polymer binders for creating semi-solid joints between pavers.

.6 Edge restraints:

.1 PVC or medium density polyethylene, industrial and flexible type edging, manufactured for use in paver installation, complete with connectors and pre-manufactured anchoring locations for spikes.

.1 Snap Edge Injection Molded Plastic Edge Restraint manufactured by Snap Edge Corporation, 519 745 9996, www.snapedge.ca; or

.2 Approved alternate.

.2 Install as per manufacturer's instructions

.7 Geotextile filter: according to Section 31 23 19.01 - Geotextiles.

.8 Cleaning compound: according to manufacturer’s instructions.

.9 Sealing compound: according to manufacturer’s instructions.

3 Execution

3.1 Manufacturer’s instructions

.1 Compliance: comply with manufacturer's written data, including product technical bulletins, product catalogue installation instructions, product carton installation instructions, and data sheets.

3.2 Protection

.1 Prevent damage to buildings, landscaping, curbs, sidewalks, trees, fences, roads and adjacent property. Make good any damage.

.2 Provide access to building, if applicable, at all times. Coordinate paving schedule to minimize interference with normal use of premises.

3.3 Subgrade

.1 Prepare subgrade according to Section 31 22 13 – Rough Grading.

.2 Ensure that subgrade preparation conforms to levels and compaction required to allow for installation of granular base.

3.4 Geotextile

.1 Install geotextile filter as indicated.

3.5 Granular base

.1 Base minimum thickness: as indicated.

.2 Spread and compact crushed stone or gravel base in uniform layers not exceeding 100 mm compacted thickness.

.3 Compact base according to Section 32 11 16.01 – Granular Sub-base.

.4 Shape and roll alternately to obtain smooth, even and uniformly compacted granular base and ensure conformity of grades with finish surface.

.5 Apply water as necessary during compaction to obtain specified density. If granular base is excessively moist, remove it and install more granular material to rid it of sponginess.

.6 In areas not accessible to rolling equipment, compact to specified density with approved mechanical tampers.

.7 Ensure top of granular base does not exceed plus or minus 10 mm over 3 m straightedge.

3.6 Structural surface

.1 Verify that structural surfaces conform to levels required for installation of unit pavers. If discrepancies occur, notify Consultant and do not commence work until instructed by Consultant.

.2 Verify that top of structural surface (top of base) does not exceed plus or minus 10 mm of grade over 3 m straightedge.

.3 Ensure that structural surface is not frozen or standing water is present during installation.

3.7 Structural curbs

.1 Verify that structural curbs conform to elevations and alignments required for installation of unit pavers. If discrepancies occur, notify Consultant and do not commence work until instructed by Consultant.

3.8 Edging

.1 Install edging true to grade, in location, layout and pattern as indicated, and according to manufacturer’s recommendations.

3.9 Bedding sand

.1 Ensure bedding material is not saturated or frozen at all times until installation is complete.

.2 Place and spread bedding sand on base or structural surface and compact as indicated.

.3 Maximum thickness after compaction: 25 mm.

.4 Screed bedding sand loose to the design profile, and screed more than one metre in advance of the laying face at the completion of work on any day.

.5 Protect unscreeded sand from precipitation.

.6 Use material other than bedding sand to compensate for depressions that exceed specified tolerances in base or structural surface.

.7 Do not use joint sand for bedding sand.

3.10 Surface course

.1 Install unit paving true to grade on the bedding sand, in location, layout and pattern as indicated. Use string lines to assist in maintaining control of alignment and pattern.

.2 Use appropriate end, edge and corner stones. Saw cut pavers to fit around obstructions and at abutting structures, cutting units accurately without damaging edges.

.3 Use masonry saw for cutting of units. Cut pieces must be tight fitting.

.4 Do not install pavers with chips, cracks, voids, discolorations or other defects.

.5 Unit paving:

.1 Prepare installation sequence and obtain approval of sequence by Consultant.

.2 Place paver pallets and other materials without exceeding load bearing capacity, or otherwise detrimentally affecting installations.

.3 Install with joint widths as indicated.

.4 Install from a minimum of three (3) bundles simultaneously to ensure acceptable colour blending.

.5 For vehicular areas, use cut pieces no smaller than one-third of a whole paver.

.6 For all other areas cut pavers minimum 75 % of the full paver dimension. Feather out within the unit paver field or row to eliminate the distinct appearance of unit paver slivers for areas requiring cut pavers.

.7 Do not place cut pavers within five (5) pavers of the end of a row or corner.

.8 Compact and level units with min. 22 kN force mechanical plate vibrator. Use minimum 19 mm thick plywood or neoprene pad

under plate compactor and over units until they are true to grade and free of movement.

.9 Do not compact unit paving within 1 m of unrestrained edges.

.10 Run equipment approved for installation only on paving surfaces vibrated in place.

.11 Complete installation after placing each 100 m^2.

.12 Inspect, remove, and replace chipped, broken and damaged pavers.

.13 Fill spaces between pavers by sweeping in dry joint sand.

.14 Pass mechanical plate vibrator over unit paving to achieve compaction of sand in joints. Ensure joints are full at completion of compaction.

.15 At completion of each work day, ensure work within 1 m of laying face is left fully compacted with sand filled joints.

.16 Surface of finished pavement: free from depressions exceeding 3 mm as measured with 3 m straight edge.

.17 Surface elevation of pavers: 3 to 4 mm above adjacent drainage inlets, concrete collars or channels.

.18 Sweep surface clean and check final elevations for conformance to drawings.

3.11 Cleaning

.1 Upon completion of installation, remove surplus materials, rubbish, tools and equipment barriers to facilitate inspection and to ensure that pavers have not been damaged during compaction.

.2 Carry out cleaning at times and conditions recommended by manufacturer of cleaning compound, immediately prior to sealing.

.3 Apply cleaning compounds appropriate for removal of various contaminants encountered according to manufacturer's recommendations.

.4 Final surface to be free of contamination.

3.12 Sealing

.1 Ensure paver surfaces to be sealed are clean, free of extraneous materials and efflorescence, dry and appropriately cured.

.2 Apply sealer according to manufacturer's recommendations.

.3 Protect sealed surfaces from trespass until sealer has dried and hardened.

End of section

1 General

1.1 Related work

.1 Section 31 22 13 – Rough Grading

.2 Section 31 32 19.01 – Geotextiles

1.2 References

.1 American Society for Testing and Materials (ASTM)

.1 Current ASTM C 136, Method for Sieve Analysis of Fine and Coarse Aggregates.

.2 Current ASTM C 117, Test Method for Material Finer Than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing.

.3 Current ASTM E 11, Specification for Wire - Cloth Sieves for Testing Purposes.

.4 Current ASTM D 4318, Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

.5 Current ASTM D 698, Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 5.5 lb. (2.49-kg) Rammer and 12-in (304.8-mm) Drop.

.2 Canadian General Standards Board (CGSB)

.1 Current CAN/CGSB-8.1, Sieves, Testing, Woven Wire, Inch Series.

.2 Current CAN/CGSB-8.2, Sieves, Testing, Woven Wire, Metric.

.3 Latest edition of Ontario Provincial Standard Specifications (OPSS):

.1 OPSS.MUNI 1010, Aggregates - Base, Subbase Select Subgrade, and Backfill Material.

1.3 Protection

.1 Prevent damage to buildings, landscaping, curbs, sidewalks, trees, fences and roads and adjacent property. Make good any damage.

.2 Provide access to building at all times. Coordinate paving schedule to minimize interference with normal use of premises.

1.4 Delivery, storage and handling

.1 Deliver, store and handle materials in accordance with Section 01 65 00 – Product Delivery Requirements.

1.5 Waste management and disposal

.1 Separate and recycle waste materials in accordance with Section 01 74 19 – Construction and Demolition Waste Management, and with the Waste Reduction Workplan.

.2 Place materials defined as hazardous or toxic waste in designated containers.

.3 Ensure emptied containers are sealed and stored safely for disposal away from children.

2 Products

2.1 Materials

.1 Granular sub-base:

.1 Crushed, pit run or screened stone, gravel or sand consisting of hard durable particles free from clay lumps, cementation, organic material, frozen material and other deleterious materials in accordance with OPSS.MUNI 1010.

.2 Gradations: within limits specified when tested to current ASTM C 136 and ASTM C 117. Sieve sizes to current CAN/CGSB-8.1 rather than ASTM E 11.

.3 Gradation Requirements:

Sieve Designation	% Passing
75 mm	100
4.75 mm	25-85
0.425 mm	5-30
0.075 mm	0-10

.2 Granular base

.1 Crushed stone or gravel: hard, durable, angular particles, free from clay lumps, cementation, organic material, frozen material and other deleterious materials.

.2 Gradations: within limits specified when tested to current ASTM C 136 and ASTM C 117. Sieve sizes to current CAN/CGSB-8.1 rather than ASTM E 11.

.3 Gradation Requirements:

Sieve Designation	% Passing
19 mm	100
12.5 mm	70-100
4.75 mm	40-70
2.00 mm	23-50
0.425 mm	7-25
0.075 mm	3-8

.4 Liquid Limit current ASTM D 4318 Maximum 25

.5 Plasticity Index current ASTM D 4318 Maximum 6

.3 Granular topping:

.1 Limestone screenings: hard, durable, crushed stone particles, free from clay lumps, cementation, organic material, frozen material and other deleterious materials.

.2 Gradations: within limits specified when tested to current ASTM C 136 and ASTM C 117.

Sieve Designation	% Passing
9.5 mm	100
4.75 mm	50-100
2.00 mm	30-65
0.425 mm	10-30
0.075 mm	5-10

.4 Stabilizer: ‘Organic-lock’ supplied by Envirobond Products Corporation, 1-866-636-8476, or approved alternate.

.5 Edging: not used.

.6 Geotextile filter: as per Section 31 32 19.01 - Geotextiles.

3 Execution

3.1 Subgrade

.1 Ensure that subgrade preparation conforms to levels and compaction required to allow for installation of granular base.

3.2 Geotextile filter

.1 Install geotextile filter as indicated.

3.3 Granular sub-base

.1 Granular sub-base material minimum thickness: as indicated.

.2 Place in layer of 150 mm compacted thickness. Compact layer to 98% Standard Density in accordance with current ASTM D 698.

3.4 Granular base

.1 Granular base material minimum thickness: as indicated.

.2 Spread and compact granular base material in uniform layers not exceeding 150 mm compacted thickness.

.3 Compact to a density of not less than 98% Standard Density in accordance with current ASTM D 698.

3.5 Granular topping

.1 Place granular topping to compacted thickness as indicated.

.2 Place in layer of 50 mm compacted thickness. Compact layer to 98% Standard Density in accordance with current ASTM D 698.

.3 Blend top 50 mm with stabilizer at a rate of 12 lbs per ton of screenings and compact as above.

3.6 Field quality control

.1 Inspection and testing of crushed stone paving will be carried out by designated testing laboratory.

.2 Costs of tests will be paid by Owner.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for concrete walks, curbs and gutters in accordance with OPSS.MUNI 351 and as amended by this section.

1.2 Related sections

.1 Section 03 30 00 – Cast-in-Place Concrete

1.3 References

.1 Current American Society for Testing and Materials International (ASTM)

.1 ASTM D698, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft^3) (600 kN-m/m^3).

.2 Current Canadian Standards Association (CSA International)

.1 CSA-A23.1, Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete.

.3 Latest edition of Ontario Provincial Standard Specifications (OPSS)

.1 OPSS.MUNI 351, Construction Specification for Concrete Sidewalk.

1.4 Submittals

.1 Submittals according to Section 01 33 00 – Submittal Procedures.

.2 Provide submittals in accordance with Section 03 30 00 – Cast-in-Place Concrete.

.3 Inform Consultant of proposed source of materials and provide access for sampling at least four (4) weeks prior to commencing work.

.4 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.5 Delivery, storage and handling

.1 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling according to Section 01 74 19.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

.2 Provide 25% Supplementary Cementing Materials (SCM) as part of Concrete Mix design.

2.2 Materials

.1 Concrete mixes and materials, reinforcing steel, joint filler and curing compound:32 MPa at 28 Days, Class C-2 Exposure in accordance with OPSS.MUNI 351, and Section 03 30 00 – Cast-in-Place Concrete.

.2 Granular base: material to Section 32 11 16.01 – Granular Sub-base.

.3 Non-staining mineral type form release agent: chemically active release agents containing compounds that react with free lime to provide water-soluble soap.

3 Execution

3.1 Grade preparation

.1 Do grade preparation work according to Section 31 11 00 – Clearing and Grubbing, Section 31 23 13 – Rough Grading and Section 31 23 33 - Excavating, Trenching and Backfilling.

3.2 Granular base

.1 Obtain Consultant's approval of subgrade before placing granular base.

.2 Place granular base material to lines, widths, and depths as indicated.

.3 Compact granular base in maximum 150 mm layers to at least 98 % of maximum density to ASTM D698.

3.3 Concrete

.1 Obtain Consultant's approval of granular base prior to placing concrete.

.2 Do concrete work according to Section 03 30 00 – Cast-in-Place Concrete.

.3 After concrete has thoroughly cured, give sidewalk a medium sandblast to achieve a uniform and consistent surface finish.

.4 Provide edging as indicated with 10 mm radius edging tool.

.5 Slip-form pavers equipped with string line system for line and grade control may be used if quality of work acceptable to Consultant can be demonstrated. Hand finish surfaces when directed by Consultant.

3.4 Tolerances

.1 Finish surfaces to within 3 mm in 3 m as measured with 3 m straightedge placed on surface.

3.5 Expansion and contraction joints

.1 Install sawcut/tooled transverse contraction joints after floating, when concrete is stiff, but still plastic, as indicated.

.2 Install expansion joints as indicated.

.3 Install expansion joints around manholes and catch basins and along length adjacent to concrete curbs, catch basins, buildings, or permanent structure.

.4 If sidewalk is adjacent to curb, make joints of curb, gutters and sidewalk coincide.

.5 Install joint filler in expansion joints according to Section 03 30 00 – Cast-in-Place Concrete as indicated.

.6 Seal expansion joints according to Section 03 30 00 – Cast-in-Place Concrete.

3.6 Curing

.1 Cure concrete by adding moisture continuously according to CSA-A23.1/A23.2 to exposed finished surfaces for at least one (1) day after placing, or sealing moisture in by curing compound as directed by Consultant.

.2 If burlap is used for moist curing, place two (2) prewetted layers on concrete surface and keep continuously wet during curing period.

.3 Apply curing compound evenly to form continuous film, according to manufacturer's requirements.

3.7 Backfill

.1 Allow concrete to cure for seven (7) days prior to backfilling.

.2 Backfill to designated elevations with adjacent material as indicated.

.3 Compact and shape to required contours as indicated.

3.8 Cleaning

.1 Proceed according to Section 01 74 00 – Cleaning and Waste Management.

.2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

End of section

1 General

1.1 Section includes

.1 Provide labour, materials, products, equipment and services to complete painted traffic lines and marking Work according to the Contract Documents.

1.2 Reference standards

.1 CAN/CGSB 1.74, Alkyd Traffic Paint.

.2 FED-STD 595B, Standard Paint Colours.

.3 OPSS 1712, Material Specification for Organic Solvent Based Traffic Paint.

.4 OPSS 1713, Material Specification for Thermoplastic Pavement Marking Material.

.5 OPSS 1714, Material Specification for Field Reacted Polymeric Pavement Marking Material.

.6 OPSS 1750, Material Specification for Traffic Paint Reflectorizing Glass Beads.

1.3 Submittals

.1 Provide submittals according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data:

.1 Submit manufacturer’s Product data indicating:

.1 Performance criteria, compliance with appropriate reference standard, characteristics, limitations and troubleshooting protocol.

.2 Product transportation, storage, handling and installation requirements.

1.4 Quality assurance

.1 Applicator's qualifications: Perform Work of this Section by a company approved by manufacturer and having specialized equipment suitable for type of work specified.

1.5 Site conditions

.1 Do not install Work of this Section outside of following environmental requirements without manufacturer's written acceptance:

.1 Durable pavement marking material: Minimum 0 °C and no forecast of rain within four (4) h of start of application.

.2 Traffic paint: Ambient air and surface temperature minimum 5 °C and maximum 43 °C. Maximum relative humidity 85 %, wind speed is less than 60 km/h and no forecast of rain within four (4) h of start of application.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Durable Paint:

.1 Hot applied thermoplastic pavement marking material: to OPSS 1713, lead-free with glass beads OPSS 1750, colour to FED-STD 595B, Hot Extruded Thermoplastic Road Markings Material by Lafrenz Road Services Ltd.; or approved alternate.

.2 Cold applied plastic pavement marking material: Flexible 2 component, solvent free and lead free, cold curing acrylic or methacrylate road marking material to OPSS 1714, with glass beads OPSS 1750, colour to FED-STD 595B, System 400 Road

Markings Materials by Lafrenz Road Services Ltd.; or approved alternate.

.2 Traffic Paint:

.1 Organic solvent based, lead-free to OPSS 1712 or CAN/CGSB 1.74.

3 Execution

3.1 Examination

.1 Verify pavement surface is properly cured. Report defects to Consultant.

.2 Commencement of Work means acceptance of existing conditions.

3.2 Installation

.1 Cold applied plastic pavement marking material [with reflectorizing glass beads] to be used for bus parking lots and driveways.

.2 Hot applied thermoplastic pavement marking material [with reflectorizing glass beads] to be used for roadways.

.3 Traffic paint to be used for all other parking areas.

3.3 Preparation

.1 Clean pavement surface and remove loose material.

.2 Verify pavement surface is free from ponding water, frozen matter, dust, oil, grease, scaling or laitance and other foreign matter detrimental to performance.

.3 Prohibit traffic in work area, until Work of this Section is complete.

3.4 Application

.1 Lay out traffic lines and markings as indicated on the Drawings and according to manufacturer's instructions.

.2 Apply durable pavement marking material using marking machine. Minimum 1.90 mm ± 0.40 mm measured dry film thickness.

.3 Apply traffic paint to achieve uniform colour and density. Coverage to be 3 sq.m/L (150 sq.ft./gal).

.4 Provide adequate shielding or masking during spray application of traffic paint.

.5 Make lines 100 mm wide unless otherwise indicated.

.6 Provide neat, straight, clean sharp edges lines. Ensure lines are uniform in colour and density.

.7 Paint markings to be within plus or minus 12 mm of dimensions indicated.

.8 Refinish ragged edges or lines incorrectly laid out. Remove incorrect lines. Make inconspicuous.

3.5 Protection

.1 Supply and install temporary barricades and traffic cones to protect freshly painted line Work from being marked or otherwise disturbed until after paint is dry.

.2 Remove temporary barricades and traffic cones when Work is complete and ready for traffic.

End of section

1 General

1.1 Section includes

.1 Fabricated swing operated perforated steel screen with metal frame attached to and supported steel support framing.

1.2 Related sections

.1 Section 05 50 00 – Metal Fabrications

.2 Section 07 46 17 – Aluminum Plank Panels

.3 Section 08 70 00 – Hardware

1.3 Administrative requirements

.1 Coordination:

.1 Coordinate method of attachment of gate assemblies to adjoining construction. Furnish setting templates and directions for installing anchorages.

.2 Coordinate installation of gate assemblies with adjacent construction to ensure that wall assemblies, flashings, trim, and joint sealants, are protected against damage from the effects of weather, age, corrosion, and other causes.

1.4 Performance requirements

.1 Design the following and similar items required to withstand live, static and dynamic loads, within acceptable deflection limitations, and the effects of earthquake motions, including comprehensive engineering analysis by a professional engineer, using performance requirements and design criteria specified or indicated, and as required by applicable codes.

1.5 Submittals for review

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data: Provide component dimensions, describe components of assemblies, anchorage and fasteners

.4 Shop Drawings: Indicate perforation, joint details, sizes, connection attachments, anchorage, size and type of fasteners, details of support framing, hardware and adjacent construction.

.1 Prepare Shop Drawings under direct supervision of a professional structural engineer.

.1 Include component structural and physical characteristics, calculations, dimensional limitations.

.2 Each shop drawing to bear seal and signature of the professional structural engineer.

.5 Samples: 200 x 200 mm sample of each finish for solid and perforated panel.

1.6 Submittals for information

.1 Qualifications Data: For fabricator, Installer, professional engineer and coating applicator.

.2 Test Reports: Submit substantiating engineering data, test results of previous tests by independent laboratory which purport to meet performance criteria, and other supportive data.

.3 Field quality control reports.

1.7 Closeout submittals

.1 Maintenance Data. Include instructions for replacing screens.

1.8 Quality assurance

.1 Fabricator and Installer: Company specializing in manufacturing the Products specified in this section with minimum five (5) years documented experience.

.2 Professional Engineer’s Qualifications: Structural engineer experienced in design and installation of the work indicated, and licensed in the Province where the Project is located.

.3 Coating Applicator Qualifications: A firm experienced in successfully applying coatings of type indicated to metals of types indicated and that employs competent control personnel to conduct continuing, effective quality-control program to ensure compliance with requirements.

1.9 Delivery, storage, and protection

.1 Protect prefinished metal surfaces with wrapping or strippable coating. Do not use adhesive papers or sprayed coatings which bond when exposed to sunlight or weather. Puncture wrappings at ends for ventilation.

1.10 Warranty

.1 Provide a five (5) year warranty starting from date of Substantial Performance to include coverage for complete system for failure to meet specified requirements.

.2 Provide a twenty (20) year warranty by manufacturer starting from date of Substantial Performance to include coverage for degradation of finish.

2 Products

2.1 Materials - general

.1 Sustainable Design: General LEED compliant material requirements:

.1 Minimum Recycled Content: Provide products that meet the minimum recycled content in Section 01 81 13 – Sustainable Design Criteria.

2.2 Manufacturer

.1 Product: Subject to compliance with requirements, approved manufactures of perforated steel screen to include:

.1 Total Gate Manufacturing Inc.; or

.2 Approved alternate manufacture.

2.3 Aluminum plank swing gate

.1 Description: Provide custom shop fabricated and finished steel Gate, swing operated, and lockable, comprising of welded wire steel infill panels panel supported by rectangular steel tube section framing. Provide fittings

and anchorages, connectors to support framing, hardware and other components required to complete installation as indicated.

.2 Perforated Screen Framing: structural steel hollow square or rectangular sections, unless otherwise indicated to attach to substrate.

.3 Vertical aluminum cladding: 25 mm x 125 mm aluminum extrusions, and prefinished end caps with wood like finish to AAMA 2605 standards:

.1 Provide “Privacy Beam Siding” with concealed mounting by Longboard or equivalent.

.4 Provide gasket and isolation between dissimilar metal components.

2.4 Hardware

.1 Provide Standard hardware as recommended and submitted for review by Consultant. Provide the following components:

.1 Gate latching lock with padlock hasp.

.2 Bolt hinges with welded hook.

.3 Refer to Section 08 70 00 – Hardware for required hardware.

2.5 Accessories

.1 Isolating Tape: Butyl, extruded, macro-polyisobutylene type, size and hardness to suit application.

.2 Welding Materials: Type required for materials being welded.

.3 Welding Filler Material: CSA-W48.

.4 Fasteners and Anchors: Corrosion-resistant, consistent with design of system.

2.6 Fabrication

.1 Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. Provide materials without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

.2 Fit and shop assemble components in largest practical sizes, for delivery to site. Shop weld components to greatest extent possible; minimize field welding.

.3 Weld plates to vertical supports; drill for anchor bolts and hardware.

.4 Cap tops of exposed vertical member with flush-welded steel plate, sloped to drain off water.

.5 Frame components: Of thickness to comply with performance requirements but not less than 2 mm nominal thickness.

.6 Prepare components to receive anchor devices. Fabricate anchors. Use exposed fasteners only where indicated; flush countersunk. Conceal other fasteners.

.7 Fabricate assemblies square and true, free from distortion, waves, twists, and buckles.

.8 Supply components required for anchorage to building structure.

2.7 Finishes

.1 Gate frame and cladding support components:

.1 Shop applied powder coat finish: Prepare material with a three (3) stage washer and zinc phosphate coating system. Thoroughly dry and apply a powder coat polyester finish in accordance with manufacturer's written instructions.

.2 Support Framing: Galvanizing as specified in Division 05 Section Metal Fabrications.

3 Execution

3.1 Examination

.1 Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, panel supports, and other conditions affecting performance of the Work.

.1 Examine wall framing to verify that structural panel support members and anchorage have been installed within alignment tolerances required by panel manufacturer.

.2 Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Preparation

.1 Supply items required to be placed in adjacent construction with setting templates, to appropriate Sections.

.2 Support Framing: Erect support framing according to Division 05 Section Metal Fabrications.

.3 Apply field paint top coats to support framing after field welding or cutting, and before perforated steel screens are installed.

3.3 Installation

.1 Install according to shop drawings.

.2 Set and align assemblies plumb and level, free of warp or twist. Maintain assembly dimensional tolerances and align adjoining components. Maintain spacings and uniform clearances between adjacent components.

.3 Securely anchor hardware support to framing, for smoother operation, and to permit sufficient adjustment to accommodate construction tolerances and other irregularities.

.4 Apply isolation tape to steel in contact with different metal or concrete

3.4 Erection tolerances

.1 Installation Tolerances: Ensure smooth operation of components, and latching of hardware. Tolerance to not exceed those required for hardware and generally as follows:

.1 Shim and align units within installed tolerance of 6 mm in 6 m, non-accumulative, on level, plumb, and location lines as indicated and within 3 mm offset of adjoining faces and of alignment of matching profiles.

3.5 Field quality control

.1 Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect completed installation, including accessories.

.2 Remove and replace where tests and inspections indicate that they do not comply with specified requirements.

.3 Prepare test and inspection reports.

3.6 Adjusting

.1 Repair finishes damaged during installation. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished on site to factory, make required alterations, and refinish entire unit or provide new units.

3.7 Cleaning

.1 Strip protective finish coverings.

.2 Clean surfaces and components.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for armourstone.

1.2 Related sections

.1 Section 31 23 33 – Excavation, Trenching and Backfilling

.2 Section 31 32 19.01 – Geotextiles

.3 Section 32 91 19.13 – Topsoil Placement and Grading

1.3 Intent

.1 Final placement and arrangement of stone may vary from the drawings.

.2 The Consultant supervision is required for final selection, placement and arrangement of all stonework.

.3 The Contractor is responsible for reviewing the placement of stonework with the Consultant.

1.4 Submittals

.1 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.2 Provide the following samples for approval by the Consultant, or arrange for the Consultant to approve the samples at the source in advance of delivery to the site:

.1 Limestone ledgerock.

.2 Filter fabric.

1.5 Delivery and storage

.1 Store stone at the source until installation on site.

.2 Stockpile and handle boulders delivered to site in a manner that will prevent breakage or scarring.

.3 Coordinate delivery of stone with the supplier.

1.6 Notification

.1 Stone shall be approved by the Consultant in writing prior to its delivery to site.

.2 Notify the Consultant ten (10) working days and again forty eight (48) hours prior to commencing placement of any rock on site.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Landscape boulders according to Contract Drawings.

.2 On-site boulders may be used if they meet the specified size and are pre-approved by the Consultant.

.3 Contractor is to source imported boulder, and Consultant is to review at the source prior to delivery and installation.

.4 Provide stone clean and free of fines, organic and deleterious materials.

.5 Provide limestone ledgerock with completely weathered surface faces.

.6 Exposed faces and ends are to be completely weathered and free of visible drill marks.

.7 Provide stones of uniform quality and rectangular in shape.

.8 Stone sizes shall vary:

.1 450 mm wide x 600 mm high x 1000 mm long.

.2 600 mm wide x 800 mm high x 1200 mm long.

.3 800 mm wide x 100 mm high x 1500 mm long.

.9 Colour: natural grey.

.10 Supplier: to be determined and as approved by the Consultant.

3 Execution

3.1 Installation

.1 Layout the stone for approval by the Consultant prior to setting into grade and backfilling.

.2 Provide a minimum of two (2) experienced and qualified staff for all phases of the stonework.

.3 At no additional cost to the Owner remove material damaged during installation as determined by the Consultant.

.4 Place landscape boulders in a horizontal orientation if possible, typically projecting 150 mm below finished grade unless otherwise shown on the drawings.

.5 Place landscape boulders to the lines, levels and top elevations indicated on the drawings unless otherwise directed by the Consultant. The plans do not intend to show exact boulder size, but do specify elevations to be met.

.6 Machine place boulders by use of belts and chains or an approved alternate method. Boulders shall not be dumped or pushed into place.

.7 Ensure crevices and openings between boulders are small enough so that backfill material cannot pass through. Abut tightly sawcut or guillotined boulders.

.8 The placement and the overall uniform appearance of the stone is critical. The Contractor may be required to remove or reset stones at his own expense in order to obtain an appearance satisfactory to the Consultant.

.9 Have the granular base compacted, inspected and approved by the Owner's approved testing agency prior to placing the stones.

.10 Dispose and replace stones damaged during installation or transportation with new at no additional cost to the Owner, unless otherwise directed by the Consultant.

.11 Make good damages damage to existing adjacent surfaces during construction and the placement of boulders.

.12 Prevent soiling, chipping or defacing of material.

.13 Place stone in depths and arrangements to ensure material and equipment below is non-visible.

.14 Do not expose to view sawcut or guillotined side .

3.2 Excess material

.1 The Contractor is responsible for removing excess stone from site at no additional cost to the Owner. The Consultant determines if stone is in excess.

End of section

1 General

1.1 Section includes

.1 Materials and installation of standard manufactured catalogue items such as waste containers, benches, planters, tables, bike racks and playground equipment.

1.2 Related sections

.1 Section 32 16 15 – Concrete Walks, Curbs and Gutters

1.3 Submittals

.1 Submit product data according to Section 01 33 00 – Submittal Procedures.

.2 Submit shop drawings according to Section 01 33 00 – Submittal Procedures.

.1 Indicate dimensions, sizes, assembly, anchorage and installation details for each furnishing specified.

.3 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.4 Provide maintenance data for care and cleaning of site furnishings for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

1.4 Waste management and disposal

.1 Separate waste materials for reuse and recycling according to Section 01 74 19 – Construction and Demolition Waste Management.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, and corrugated cardboard packaging material in appropriate on-site bins for recycling according to Waste Management Plan.

.4 Separate for reuse and recycling and place in designated containers Steel, Metal, and Plastic waste according to Waste Management Plan.

.5 Fold up metal banding, flatten and place in designated area for recycling.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Bench

.1 Model # MBE-1050-00077. 1050 Backed Bench by Maglin or approved alternate: 30.06 in. height x 70 in. length, formed steel frame, Ipe wood seat and back, 70 in. long back, Titanium colour (fine-textured/matte finish). Quantity 1.

.2 Model # MBR-0150-00002. 150 Bike Rack by Maglin or approved alternate: h.s.steel tube and steel mounting plate, surface mount, 2-bike configuration, Titanium colour (fine-textured/matte finish). Quantity 3.

.3 Contact: Maglin. 1-800-716-5506. sales@maglin.com

3 Execution

3.1 Installation

.1 Assemble furnishings according to manufacturer's instructions.

.2 Install furnishing true, plumb, and firmly anchored.

.3 Touch-up damaged finishes to approval of Consultant.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for topsoil placement and grading.

1.2 Related sections

.1 Section 31 11 00 – Clearing and Grubbing

.2 Section 31 22 13 – Rough Grading

.3 Section 31 32 19.01 – Geotextiles

1.3 References

.1 Agriculture and Agri-Food Canada

.1 The Canadian System of Soil Classification, Third Edition, 1998.

.2 Current Canadian Council of Ministers of the Environment

.1 PN1340, Guidelines for Compost Quality.

.3 Current Canadian Green Building Council (CaGBC)

.1 LEED Canada-NC Version 1.0, LEED (Leadership in Energy and Environmental Design): Green Building Rating System For New Construction and Major Renovations.

1.4 Definitions

.1 Compost:

.1 Mixture of soil and decomposing organic matter used as fertilizer, mulch, or soil conditioner.

.2 Compost is processed organic matter containing 40 % or more organic matter as determined by Walkley-Black or Loss On Ignition (LOI) test.

.3 Product must be sufficiently decomposed (i.e. stable) so that any further decomposition does not adversely affect plant growth (C:N ratio below 25), and contain no toxic or growth inhibiting contaminates.

.4 Composed bio-solids to: CCME Guidelines for Compost Quality, Category A.

1.5 Submittals

.1 Provide submittals according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Quality control submittals:

.1 Soil testing: submit certified test reports showing compliance with specified performance characteristics and physical properties as described in PART 2 - SOURCE QUALITY CONTROL.

.2 Certificates: submit product certificates signed by manufacturer certifying materials comply with specified performance characteristics and criteria and physical requirements.

1.6 Testing

.1 All topsoil shall be tested for Nitrogen (N), Phosphorous (P), Potassium (K), Potash and minor element values, soluble salt contents, organic matter, atrazine and pH value in order to determine the amount and type of fertilizer or additives to be applied for specific areas.

.2 Test topsoil within thirty (30) working days of scheduled planting.

1.7 Quality assurance

.1 Pre-installation meetings: conduct pre-installation meeting to verify project requirements, installation instructions and warranty requirements.

1.8 Waste management and disposal

.1 Separate waste materials for reuse and recycling according to Section 01 74 19 – Construction and Demolition Waste Management.

.2 Divert unused soil amendments from landfill to official hazardous material collections site approved by Consultant.

.3 Do not dispose of unused soil amendments into sewer systems, into lakes, streams, onto ground or in locations where it will pose health or environmental hazard.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Topsoil source

.1 Use topsoil from stockpiled work carried out under Section 31 22 13 – Rough Grading.

.2 Use additional imported topsoil if necessary. Advise Consultant of topsoil source to be utilized with sufficient lead time for testing.

.3 Topsoil shall be a screened, fertile, friable, natural loam containing not less than 4 % organic matter for clay loams and not less than 2% organic matter for sandy loams to a maximum of 15 %.

.4 Topsoil shall be capable of sustaining vigorous plant growth, free of subsoil contamination, roots and stones over 30 mm in diameter and weeds, with a pH ranging from 6.5 to 7.0.

2.3 Topsoil quality

.1 Topsoil for seeded and sodded areas: mixture of particulates, micro organisms and organic matter which provides suitable medium for supporting intended plant growth.

.1 Soil texture based on The Canadian System of Soil Classification, to consist of 20 to 70 % sand, minimum 7 % clay, and contain 2 to 10 % organic matter by weight.

.2 Contain no toxic elements or growth inhibiting materials.

.3 Finished surface totally free from:

.1 Stones, roots, debris, subsoil, clay lumps, weeds, weed seeds or other solid or deleterious materials.

.4 Consistency: friable when moist.

2.4 Planting mixture

.1 Planting mixture for continuous planting beds and tree pits shall be six (6) parts topsoil, two (2) partwell-rotted manure, 1 part peat moss, and 0.75 kg superphosphate (Triple mix).

2.5 Soil amendments

.1 Fertilizer:

.1 Conform to recommendations from soil testing agency with respect to improvements for tested topsoil and apply as specified for each condition.

.2 Industry accepted standard medium containing nitrogen, phosphorous, potassium and other micro-nutrients suitable to specific plant species or application or defined by soil test.

.2 Peatmoss:

.1 Derived from partially decomposed species of Sphagnum Mosses.

.2 Elastic and homogeneous, brown in colour.

.3 Free of wood and deleterious material which could prohibit growth.

.4 Shredded particle minimum size: 5 mm.

.3 Sand: washed coarse silica sand, medium to course textured.

.4 Organic matter: compost Category A according to current CCME PN1340, unprocessed organic matter, such as rotted manure, hay, straw, bark residue or sawdust, meeting the organic matter, stability and contaminant requirements.

.5 Use composts meeting Category B requirements for land fill reclamation and large scale industrial applications.

.6 Limestone:

.1 Ground agricultural limestone.

.2 Gradation requirements: percentage passing by weight, 90 % passing 1.0 mm sieve, 50 % passing 0.125 mm sieve.

2.6 Source quality control

.1 Advise Consultant of sources of topsoil and/or manufactured topsoil to be utilized with sufficient lead time for testing.

.2 Contractor is responsible for costs related to soil testing and required amendments to supply topsoil as specified.

.3 Soil testing by recognized testing facility for PH value, N, P and K, and organic matter, soluble salt contents, and atrazine in order to determine the amount and type of fertilizer or additives to be applied for specific areas.

.4 Testing of topsoil will be carried out by testing laboratory approved by Consultant.

.1 Soil sampling, testing and analysis to be according to Provincial standards.

.2 Testing laboratory to be a certified facility accredited by the Canadian Association of Environmental Analytical Laboratories (CAEAL) and/or the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).

.5 Submit two (2) copies of the soil analysis and recommendations to the Consultant prior to amending or importing topsoil.

.6 Amend stockpiled or imported topsoil source according to testing recommendations and re-test at no additional cost to the Owner. Re-submit two (2) copies of the soil analysis to the Consultant for approval.

3 Execution

3.1 Temporary erosion and sedimentation control

.1 Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction OR sediment and erosion control drawings.

.2 Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

.3 Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.2 Verification of constructed rough grade

.1 Verify that grades are correct.

.1 If discrepancies occur, notify Consultant and do not commence work until instructed by Consultant.

.2 Allow for minor adjustments to rough grade, eliminating uneven areas and low spots, ensuring positive drainage.

.3 Remove debris, roots, branches, stones in excess of 50 mm diameter and other deleterious materials.

.1 Remove soil contaminated with calcium chloride, toxic materials and petroleum products if it was contaminated from the time of rough grade acceptance.

.2 Remove debris which protrudes more than 50 mm above surface.

.3 Dispose of removed material off site.

.4 Cultivate entire area which is to receive topsoil to minimum depth of 100 mm.

.1 Cross cultivate those areas where equipment used for hauling and spreading has compacted soil.

3.3 Placing and spreading of topsoil/planting mixture

.1 Place topsoil after Consultant has accepted subgrade.

.2 Spread topsoil in uniform layers not exceeding 150 mm.

.3 For sodded areas keep topsoil 15 mm below finished grade.

.4 Spread topsoil to following minimum depths after settlement.

.1 150 mm for seeded areas.

.2 135 mm for sodded areas.

.3 Place required depth of planting mixture for continuous planting beds and tree pits as indicated on the details.

.5 Manually spread topsoil/planting soil around trees, shrubs and obstacles.

3.4 Soil amendments

.1 For specialty areas noted on plan or designated in the soil test results, apply and thoroughly mix soil amendments into the full specified depth of topsoil at recommended rates.

3.5 Finish grading

.1 Grade to eliminate rough spots and low areas and ensure positive drainage.

.1 Prepare loose friable bed by means of cultivation and subsequent raking.

.2 Consolidate topsoil to required bulk density using equipment approved by Consultant.

.1 Leave surfaces smooth, uniform and firm against deep footprinting.

3.6 Acceptance

.1 Consultant will determine acceptance of material, depth of topsoil and finish grading.

3.7 Surplus material

.1 Dispose of materials except topsoil not required off site.

3.8 Cleaning

.1 Proceed according to Section 01 74 00 – Cleaning and Waste Management.

.2 Upon completion of installation, remove surplus materials, rubbish, tools and equipment barriers.

End of section

1 General

1.1 Section includes

.1 Materials and installation for a new. pneumatic blower applied, vegetated surface composed of an organic growing media injected with the specified seed mix.

1.2 Related sections

.1 Section 31 11 00 – Clearing and Grubbing

.2 Section 31 22 13 – Rough Grading

.3 Section 32 91 19.13 – Topsoil Placement and Grading

1.3 Submittals

.1 Submit in according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.4 Quality assurance

.1 The surface must be constructed with a pneumatic blower unit complete with a supplemental granular injection system capable of installing at least 15 cubic metres per hour.

.2 Terraseeding must be performed by seeding contractors with the required specialized equipment and knowledgeable technicians. These Contractors include:

.1 Dol Hydroseeding Inc., Cookstown, ON (705) 458-4353;

.2 Landsource Organix, Hornby, ON 1-877-548-8558;

.3 Hermanns Contracting Ltd., Schomberg, ON (905) 939-1230; or

.4 Approved alternate.

1.5 Scheduling

.1 Schedule Terraseeding to follow the completion of tree and shrub planting.

.2 Complete terraseed in the spring, during the months of April and May, or in the fall, in the month of September. Terraseeding outside of these time constraints must be approved by the Consultant.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Seed mix

.1 Canadian “Certified” seed, “Canada No. 1 Ground Cover Mixture” according to the Government of Canada Seeds Act and Regulations.

.2 Provide the following certified varieties of seed mix percentages for Terraseeding:

.1 Mix A – Tableland Grass Mixture (500 g / 180 m^2)

.1	Big Bluestem (Andropogon gerardii)	25 %
.2	Canada Wild Rye (Elymus canadensis)	20 %
.3	Indiangrass (Sorghastrum nutans)	20 %
.4	Little Blue Stem (Schizachyrium scoparium)	10 %
.5	Prairie Cord Grass (Spartina pectinata)	5 %
.6	Switchgrass (Panicum virgatum)	20 %

.2 Mix B – Native Prairie Meadow Mixture (500 g / 180 m^2)

.1	Black Eyed Susan (Rudbeckia hirta)	7 %
.2	Early Goldenrod (Solidago juncea)	1 %
.3	Fowl Bluegrass (Poa palustris)	25 %
.4	Foxglove/Beardtongue (Penstemon digitalis)	2 %
.5	Indiangrass (Sorghastrum nutans)	20 %
.6	Little Bluestem (Schizachyrium scoparium)	15 %
.7	New England Aster (Aster novae-angliae)	1 %

.8	Showy Tick Trefoil (Desmodium canadense)	1 %
.9	Switchgrass (Panicum virgatum)	25%
.10	White Vervain (Verbena urticifolia)	1%
.11	Wild Bergamot (Monarda fistulosa)	2 %

.3 Mix C – Flowering Lawn Mixture (1.5 kg / 135 m^2)

.1	Birdsfoot Trefoil (Lotis corniculatus)	20 %
.2	Chamomile (Matricaria chamomilla)	1 %
.3	Creeping Red Fescue (Festuca rubra)	30 %
.4	English Daisy Bells (Bellis perennis)	1 %
.5	Sheeps Fescue (Festuca ovina)	27 %
.6	Thrift (Armeria maritima)	1 %
.7	White Clover (Trifolium repens)	20 %

.4 Mix D – Standard OBL Wetland Native Mixture (500 g / 180 m2)

.1 Awl Sedge (1%)
.2 Blunt Broom Sedge (10%)
.3 Boneset (1%)
.4 Fox Sedge (25%)
.5 Giant Bur Reed (4%)
.6 Lurid Sedge (4%)
.7 Nodding Bur Marigold (2%)
.8 Nodding Sedge (5%)Purple Stemmed Aster (1%)
.9 Soft Rush (2%)
.10 Spotted Joe Pye Weed (1%)
.11 Square Stemmed Monkey Flower (1%)
.12 Swamp Milkweed (1%)
.13 Tussock Sedge (1%)
.14 Virginia Wild Rye (40%)
.15 Wool Grass (1%)

.3 In packages individually labelled according to “Seeds Regulations” and indicating name of supplier.

4. Contact Ontario Seed Company (OSL) at 1-800-465-5849, Info@oscseeds.com. Submit alternate in accordance with Section 01 25 00 - Substitution Procedures.

2.3 Compost growing medium

.1 Particle size – 99 % passing through a 25 mm sieve.

.2 Must be derived from 100 % well-decomposed green waste organic matter produced by composting sites that meet or exceed MOE Compost Regulation 101 as well as meeting the Canadian Council of Ministers of the Environment's (CCME) definition for Type 'A' Compost.

.3 Submit proof of compost quality meeting CCME guidelines by an approved laboratory to the Consultant for approval prior to installation.

3 Execution

3.1 Workmanship

.1 Provide terraseeding as shown on the plan or as directed by the Consultant.

.2 Do not apply material onto structures, signs, guide rails, fences, plant material, utilities and other than surfaces intended. Clean up immediately, any material applied where not intended, to satisfaction of the Consultant.

.3 Do not perform work under adverse field conditions such as wind speeds over 10 km/h, frozen ground or ground covered with snow, ice or standing water.

.4 Protect seeded areas from trespassing until seeded areas are established.

3.2 Seed bed preparation

.1 Verify that grades are correct. If discrepancies occur, notify the Consultant and do not commence work until instructed by the Consultant.

.2 Clear and grub areas designated for seeding as indicated according to Section 31 11 00 – Clearing and Grubbing.

.3 Rototill areas designated for seeding to a depth of 150 mm. Remove debris, roots, branches, stones in excess of 50 mm diameter and other

materials unsuitable for landscaping from the finished surface. Dispose of surplus material off site at Contractor's expense.

.4 Excavate and remove overburden and install topsoil to a depth of 450 mm in the area where Mix 'D' is to be applied.

.5 Rake designated seeding areas to eliminate any uneven grades as directed by the Consultant.

.6 Ensure areas to be seeded are moist to depth of 150 mm before seeding.

3.3 Preparation of terraseed

.1 Measure quantities of materials by weight or weight-calibrated volume measurement. Supply equipment required for this work.

3.4 Terraseeding application

.1 Uniformly apply terraseeding directly at the soil surface with a pneumatic blower. Install compost and seed mix to a minimum thickness of 50 mm.

.2 Blend application 500 mm into adjacent grass areas or sodded areas to form uniform surfaces.

.3 Reapply where application is not uniform.

3.5 Maintenance during establishment period

.1 Perform following operations from time of seed application until acceptance by the Consultant:

.1 Water seeded area to maintain optimum soil moisture level for germination and continued growth of grass. Control watering to prevent washouts.

.2 Repair and reseed dead or bare spots to allow establishment of seed prior to acceptance.

3.6 Final acceptance

.1 Seeded areas will be accepted by the Consultant provided that:

.1 Areas are uniformly established and free of weeds and rutted, eroded, dead or bare spots.

.2 Areas seeded in fall will be accepted in following spring, one month after start of growing season, provided all acceptance conditions are fulfilled.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for sodding.

1.2 Related sections

.1 Section 01 33 00 – Submittal Procedures

.2 Section 01 74 19 – Construction and Demolition Waste Management

.3 Section 32 91 19.13 – Topsoil Placement and Grading

1.3 Submittals

.1 Samples.

.1 Submit samples according to Section 01 33 00 – Submittal Procedures.

.2 Submit:

.1 Sod for each type specified.

.1 Install approved samples in one square metre mock-ups and maintain according to maintenance requirements during establishment period.

.2 Bio-degradable geotextile fabric.

.3 Obtain approval of samples by Consultant.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

1.4 Quality assurance

.1 Test Reports: certified test reports showing compliance with specified performance characteristics and physical properties.

.2 Certificates: product certificates signed by manufacturer certifying materials comply with specified performance characteristics and criteria and physical requirements.

.3 Pre-Installation Meetings: conduct pre-installation meeting to verify project requirements, installation instructions and warranty requirements.

1.5 Scheduling

.1 Schedule delivery and sod laying to coincide with preparation of soil surface.

.2 Schedule sod installation when frost is not present in ground.

1.6 Waste management and disposal

.1 Separate and recycle waste materials according to Section 01 74 19 – Construction and Demolition Waste Management .

.2 Divert unused fertilizer from landfill to official hazardous material collections site approved by Consultant.

.3 Do not dispose of unused fertilizer into sewer systems, into lakes, streams, onto ground or in locations where it will pose health or environmental hazard.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Number One Turf Grass Nursery Sod: sod that has been especially sown and cultivated in nursery fields as turf grass crop.

.1 Turf Grass Nursery Sod types:

.1 Number One Kentucky Bluegrass Sod: Nursery Sod grown solely from seed of cultivars of Kentucky Bluegrass, containing not less than 50 % Kentucky Bluegrass cultivars.

.2 Number One Kentucky Bluegrass Sod - Fescue Sod: Nursery Sod grown solely from seed mixture of cultivars of Kentucky Bluegrass and Chewing Fescue or Creeping Red Fescue, containing not less than 40% Kentucky Bluegrass cultivars and 30 % Chewing Fescue or Creeping Red Fescue cultivar(s).

.3 Number One Named Cultivars: Nursery Sod grown from certified seed.

.2 Turf Grass Nursery Sod quality:

.1 Not more than two (2) broadleaf weeds or ten (10) other weeds per 40 m^2.

.2 Density of sod sufficient so that no soil is visible from height of 1,500 mm when mown to height of 50 mm.

.3 Mowing height limit: 35 to 65 mm.

.4 Soil portion of sod: 6 to 15 mm in thickness.

.2 Commercial Grade Turf Grass: sod that has not been grown as Turf Grass Nursery Sod crop.

.1 Mow sod at height directed by Consultant within thirty six (36) hours prior to lifting, and remove clippings.

.3 Sod establishment support:

.1 Biodegradable starch pegs: 17 x 8 x 200 mm.

.4 Water:

.1 Potable, free of impurities.

.5 Fertilizer:

.1 To Canada "Fertilizers Act" and "Fertilizers Regulations".

.2 Complete, synthetic, slow release with 65 % of nitrogen content in water-insoluble form.

2.3 Source quality control

.1 Obtain approval from Consultant of sod at source.

.2 When proposed source of sod is approved, use no other source without written authorization from Consultant.

3 Execution

3.1 Preparation

.1 Verify that grades are correct and prepared according to Section 32 91 19.13 – Topsoil Placement and Grading. If discrepancies occur, notify Consultant and do not commence work until instructed by Consultant.

.2 Do not perform work under adverse field conditions such as frozen soil, excessively wet soil or soil covered with snow, ice, or standing water.

.3 Fine grade surface free of humps and hollows to smooth, even grade, and elevations indicated, and to tolerance of plus or minus 8 mm for Turf Grass Nursery Sod and plus or minus 15 mm for Commercial Grade Turf Grass Nursery Sod. Surface to drain naturally.

.4 Remove and dispose of weeds; debris; stones 25 mm in diameter and larger; soil contaminated by oil, gasoline and other deleterious materials off site.

3.2 Sod placement

.1 Lay sod within thirty six (36) hours of being lifted.

.2 Lay sod sections in rows, joints staggered. Butt sections closely without overlapping or leaving gaps between sections. Cut out irregular or thin sections with sharp implements.

.3 Roll sod to provide close contact between sod and soil. Use of heavy roller to correct irregularities in grade is not permitted.

3.3 Sod placement on slopes and pegging

.1 Start laying sod at bottom of slopes.

.2 Lay sod sections longitudinally along contours of slopes.

.3 All swales to be sodded.

.4 Peg sod on slopes steeper than three (3) horizontal to one (1) vertical, within 1 m of catch basins and within 1 m of drainage channels and ditches to following pattern:

.1 100 mm below top edge at 200 mm on centre for first sod sections along contours of slopes.

.2 Not less than four (4) pegs per square metre.

.3 Not less than six (6) pegs per square metre in drainage channels. Adjust pattern as directed by Consultant.

.4 Drive pegs to 50 mm above soil surface of sod sections.

3.4 Fertilizing program

.1 Amend topsoil for sodded areas using soil test analysis results as specified in Section 32 91 19.13 – Topsoil Placement and Grading.

.2 Fertilize during establishment and warranty periods to following program:

Month	Day	Rate	Ratio
Sept	15 to 30	350 kg/ha	6:6:12
April	15 to 30	350 kg/ha	12:8:8

3.5 Maintenance during establishment period

.1 Perform following operations from time of installation until acceptance.

.2 Water sodded areas in sufficient quantities and at frequency required to maintain optimum soil moisture condition to depth of 75 to 100 mm.

.3 Cut grass as many times as required until Substantial Completion, to 50 mm when or prior to it reaching height of 75 mm. Remove clippings which will smother grassed areas as directed by Consultant.

.4 Maintain sodded areas weed free 95 %.

.5 Fertilize areas according to fertilizing program. Spread half of required amount of fertilizer in one direction and remainder at right angles and water in well.

3.6 Acceptance

.1 Turf Grass Nursery Sod areas will be accepted by Consultant provided that:

.1 Sodded areas are properly established.

.2 Sod is free of bare and dead spots.

.3 No surface soil is visible from height of 1,500 mm when grass has been cut to height of 50 mm.

.4 Sodded areas have been cut minimum two (2) times prior to acceptance.

.5 At least four (4) weeks have elapsed since laying.

.2 Sodded Commercial Grade Turf Grass Nursery Sod areas will be accepted by Consultant provided that:

.1 Sodded areas are properly established.

.2 Extent of surface soil visible when grass has been cut to height of 60 mm is acceptable.

.3 Sod is free of bare or dead spots and extent of weeds apparent in grass is acceptable.

.4 Sodded areas have been cut minimum two (2) times prior to acceptance.

.5 Fertilizing according to fertilizer program has been carried out at least once.

.3 Areas sodded in fall will be accepted in following spring one month after start of growing season provided acceptance conditions are fulfilled.

3.7 Maintenance During Warranty Period

.1 Perform following operations from time of acceptance until end of warranty period:

.1 Water sodded Turf Grass Nursery Sod and Commercial Grade Turf Grass Nursery Sod areas in sufficient quantities and at frequencies required to maintain optimum soil moisture conditions to depth of 75 to 100 mm.

.2 Repair and resod dead or bare spots to satisfaction of Consultant and in accordance with Subsection 803.07.05 of OPSS.MUNI 803 is amended by the addition of the following:

> “If surface soil should be visible between the rolls of sod the Contractor Administrator may, at his sole discretion, request the Contractor to correct the open joints by providing topsoil and seed, in lieu of repositioning the displaced rolls of sod.”

.3 Cut grass and remove clippings that will smother grass as directed by Consultant to height as follows:

.1 Turf Grass Nursery Sod:

.1 50 mm during normal growing conditions.

.2 Commercial Grade Turf Grass Nursery Sod:

.1 60 mm during normal growing conditions.

.3 Cut grass at two (2) week intervals, but at intervals so that approximately one third of growth is removed in single cut.

.4 Fertilize areas according to fertilizing program. Spread half of required amount of fertilizer in one direction and remainder at right angles and water in well.

.5 Maintain sodded areas 95 % weed free.

3.8 Cleaning

.1 Upon completion of installation, remove surplus materials, rubbish, tools and equipment barriers.

End of section

1 General

1.1 Section includes

.1 Materials and installation for plant material, accessories, mulch, planting, tree support, mulching and maintenance.

1.2 Related sections

.1 Section 31 22 13 – Rough Grading

.2 Section 32 91 19.13 – Topsoil Placement and Grading

1.3 References

.1 Agriculture and Agri-Food Canada (AAFC).

.1 Current Plant Hardiness Zones in Canada.

.2 Canadian Nursery Landscape Association (CNLA).

.1 Current Canadian Standards for Nursery Stock.

.3 Department of Justice Canada (Jus).

.1 Canadian Environmental Protection Act (CEPA), 1999, c. 33.

.2 Transportation of Dangerous Goods Act (TDGA), 1992, c.34.

.4 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.5 Ontario Provincial Standard Specification (OPSS).

.1 OPSS.MUNI 801: The Protection of Trees.

.6 Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA).

.7 Canadian Association for Environmental Analytical Laboratories (CAEAL).

.8 American Association of Nurserymen (AAN).

.1 Z60,01, Nursery Stock.

.9 Hortus Third, Liberty Hyde Bailey, Hortorium.

.10 Agriculture Canada.

.1 Publication 1507. The Pruning Manual.

1.4 Definitions

.1 Mycorrhiza: association between fungus and roots of plants. This symbiosis, enhances plant establishment in newly landscaped and imported soils.

1.5 Submittals

.1 Make submittals according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled 'LEED v4 Material Reporting Form- Low Emitting'

.2 APPENDIX-C to Section 01 81 13 titled 'LEED v4 Material Reporting Form'

.3 Submit product data for:

.1 Fertilizer.

.2 Anti-desiccant.

.3 Guying assembly including clamps, collar, guying wire, anchors and wire tightener.

.4 Mulch

.5 Trunk protection.

.4 Submit WHMIS MSDS - according to Section 01 33 00.

.5 Submit samples for:

.1 Mulch.

.2 Planting mixture.

1.6 Quality assurance

.1 Execute work of this section by qualified personnel employed by a licensed Contractor, under the direction and supervision of a foreman with membership in Landscape Ontario, and who is known to have been responsible for satisfactory installations during a period of at least five (5) years.

.2 Health and Safety:

.1 Do construction occupational health and safety according to Section 01 35 29 – Health and Safety Procedures

1.7 Storage and protection

.1 Protect plant material from frost, freezing, excessive heat, wind and sun during delivery.

.2 Secure and manage stockpiled plant material from theft.

.3 Immediately store and protect plant material which will not be installed within 1 hour after arrival at site in an approved shaded site storage location.

.4 Plant material delivered to site within five (5) days of arrival on site. Plant material not installed within five (5) days of arrival on site will not be accepted.

.5 Water stockpiled plant material daily prior to installation.

.6 Protect plant material from damage during transportation:

.1 If delivery distance is less than 30 km and vehicle travels at speeds under 80 km/h, tie tarpaulins around plants or over vehicle box.

.2 If delivery distance exceeds 30 km or vehicle travels at speeds over 80 km/h, use enclosed vehicle.

.3 Protect foliage and root balls using anti-desiccants and tarpaulins, if use of enclosed vehicle is impractical due to size and weight of plant material.

.4 Keep cool all plant material delivered in an enclosed vehicle for duration of transport.

.7 Protect stored plant material from frost, wind and sun and as follows:

.1 For bare root plant material, preserve moisture around roots by heeling-in or burying roots in sand or topsoil and watering to full depth of root zone.

.2 For pots and containers, maintain moisture level in containers. Heel-in fibre pots.

.3 For balled and burlapped and wire basket root balls, place to protect branches from damage. Maintain moisture level in root zones.

.8 Store and manage hazardous materials according to Section 01 65 00 - Product Delivery Requirements: Construction.

.9 Waste Management and Disposal:

.1 Separate waste materials for reuse and recycling according to Section 01 74 19 – Construction and Demolition Waste Management.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene and corrugated cardboard packaging material for recycling according to Waste Management Plan (WMP).

.4 Separate for reuse and recycling and place in designated containers Steel, Metal, and Plastic waste according to WMP.

.5 Place materials defined as hazardous or toxic in designated containers.

.6 Handle and dispose of hazardous materials according to CEPA, TDGA, and Regional and Municipal regulations.

.7 Divert unused metal materials from landfill to approved metal recycling facility.

.8 Fold up metal and plastic banding, flatten and place in designated area for recycling.

.9 Divert discarded plastic plant containers materials from landfill to approved plastic recycling facility.

.10 Dispose of unused fertilizer at approved official hazardous material collection site.

.11 Dispose of unused anti-desiccant at approved official hazardous material collections site.

.12 Divert unused wood and mulch materials from landfill to approved recycling or composting facility.

1.8 Scheduling

.1 Provide a detailed planting schedule for specified plant material four (4) weeks minimum prior to commencing the Work.

.2 Obtain approval for the planting program schedule from the Consultant 7 days in advance of shipment of plant material.

.3 Plant only under conditions that are conducive to the health and best physical condition of plant materials.

.4 Schedule of planting program to include:

.1 Quantity and type of plant material.

.2 Shipping dates.

.3 Arrival dates on site.

.4 Planting dates.

.5 Duration of planting operations.

.5 Coordinate shipping of plants and planting operations to ensure minimum time lapse between digging and planting.

.6 Extended planting operations over a long period of time with a limited crew will not be accepted.

1.9 Warranty

.1 The Contractor hereby warrants that plant material as itemized on plant list will remain free of defects for two full growing seasons from the date of Substantial Performance.

.2 End of warranty inspection will be conducted by the Consultant. Attendance by the Contractor is mandatory.

.3 The Consultant reserves the right to extend Contractor's warranty responsibilities for an additional one year if, at end of initial warranty period, leaf development and growth is not sufficient to ensure future survival.

2 Products

2.1 Sustainable requirements

.1 Materials and products according to 01 81 13 - Sustainable Design Criteria.

2.2 Planting mixture

.1 Planting mixture to be 6 parts topsoil, two (2) parts decomposed weed-free manure, one (1) part peat moss and 0.75 kg superphosphate (Triple Mix).

2.3 Plant material

.1 Plant material to conform to the plant list shown on the drawings.

.2 Substitutions for specified plants require the Consultant's written approval.

.3 Type of root preparation, sizing, grading and quality: comply to Canadian Standards for Nursery Stock.

.4 Source of plant material: grown in Zone 4 according to Plant Hardiness Zones in Canada.

.5 Plant material must be planted in zone indicated as appropriate for its species.

.6 Plant material in location appropriate for its species.

.7 Plant material: free of disease, insects, defects or injuries and structurally sound with strong fibrous root system.

.8 Trees: with straight trunks, well and characteristically branched for species except if specified otherwise.

.9 Trees larger than 200 mm in caliper: half root pruned during each of two successive growing seasons, the latter at least one growing season prior to arrival on site.

.10 Bare root stock: nursery grown, in dormant stage, not balled and burlapped or container grown.

.11 Collected stock: not permitted.

.12 Conifers: spring dug, selected by Consultant prior to digging.

2.4 Water

.1 Free of impurities that would inhibit plant growth.

2.5 Stakes

.1 Heartwood, pointed one end, 38 x 38 x 2300 mm.

2.6 Wire tightener

.1 Not applicable.

2.7 Guying wire

.1 ArborTie R GREEN, (3) 3,048 mm lengths, by Deep Root Partners, L.P., 1 (800)- 458-7668; or

.2 Approved alternate.

2.8 Clamps

.1 Not applicable.

2.9 Anchors

.1 Roofing nail, galvanized, 25 mm long.

2.10 Guying collar

.1 Not applicable.

2.11 Trunk protection

.1 Burlap: clean, minimum 2.5 kg/m^2 mass and 150 mm wide, and twine fastener.

.2 Rodent guard:

.3 Welded wire mesh or PVC trunk guard. No dark coloured materials.

.4 Bottom of guard to be 50 mm below finished grade. Check and adjust guards every fall to ensure they are mouse tight, free of trash and not interfering with root or trunk development.

2.12 Mulch

.1 Cedar bark chip: varying in size from 25 to 50 mm in diameter, free of small branches and leaves.

2.13 Fertilizer

.1 Synthetic commercial type as recommended by soil test report.

2.14 Anti-desiccant

.1 Wax-like emulsion.

2.15 Flagging tape

.1 Fluorescent, orange or green colour.

2.16 Samples

.1 Submit two (2) samples of each product for Consultant's approval prior to planting.

.2 Retain approved samples on site in a readily available location. Products used must conform to approved samples.

2.17 Source quality control

.1 Provide source and availability of specified plant material four (4) weeks minimum prior to commencing Work.

.2 Arrange for inspection of the plant material by the Consultant at the source of the supply, seven (7) days minimum prior to the scheduled shipment of the material.

.3 Obtain written approval from Consultant of plant material prior to planting.

.4 Imported plant material must be accompanied with necessary permits and import licenses. Conform to Federal, Provincial or Territorial regulations.

3 Execution

3.1 Pre-planting preparation

.1 Do construction occupational health and safety according to Section 01 35 29 – Health and Safety Procedures.

.2 Ensure plant material on site is acceptable to the Consultant.

.3 Deliver all materials in their original containers with all labels intact and legible. Clearly indicate contents, weight, analysis, and manufacturer's name for containers with additives.

.4 Remove damaged roots and branches from plant material.

.5 Apply anti-desiccant to conifers and deciduous trees in leaf according to manufacturer's instructions.

3.2 Excavation and preparation of planting beds

.1 Establishment of sub-grade for planting beds is specified in Section 31 22 13 – Rough Grading.

.2 Preparation of planting beds is specified in Section 32 91 19.13 – Topsoil Placement and Grading.

.3 For individual planting holes:

.1 Stake out location of tree pits and shrub beds and obtain approval from the Consultant prior to excavating.

.2 Excavate to depth and width as indicated.

.3 Remove rocks, roots, debris and toxic material from excavated material that will be used as planting soil for trees and individual shrubs. Dispose of excess material.

.4 Scarify sides and bottom of tree pits and shrub beds.

.5 Remove water which enters excavations prior to planting. Notify the Consultant if water source is ground water.

3.3 Inspection

.1 Plant material will be inspected by the Consultant upon delivery to site, prior to unloading.

.2 Provide delivery receipt to Consultant at time of delivery.

.3 Remove material not specified immediately and have replacements shipped within two (2) working days.

.4 Coordinate inspection by Consultant prior to planting operations.

3.4 Planting

.1 For bare root stock, place 50 mm backfill soil in bottom of hole. Plant trees and shrubs with roots placed straight out in hole.

.2 For jute burlapped root balls, cut away top one third of wrapping and wire basket without damaging root ball. Do not pull burlap or rope from under root ball.

.3 For container stock or root balls in non-degradable wrapping, remove entire container or wrapping without damaging root ball.

.4 Plant vertically in locations as indicated. Orient plant material to give best appearance in relation to structure, roads and walks.

.5 For trees and shrubs:

.1 Backfill soil in 150 mm lifts. Tamp each lift to eliminate air pockets. If two thirds of depth of planting pit has been backfilled, fill remaining space with water. After water has penetrated into soil, backfill to finish grade.

.2 Form watering saucer as indicated.

.3 Install filter fabric over tree saucers prior to mulching.

.4 Install filter fabric over entire shrub bed areas and cut slits to accommodate shrub root balls prior to mulching.

.6 For ground covers, backfill soil evenly to finish grade and tamp to eliminate air pockets. Do not install filter fabric in areas to be planted with ground covers.

.7 Install all plant material 75 mm high relative to finished grades to allow for natural settlement.

.8 Water plant material thoroughly.

.9 After soil settlement has occurred, fill with soil to finish grade.

.10 Dispose of burlap, wire and container material off site.

3.5 Trunk protection

.1 Install trunk protection on deciduous trees as indicated and in accordance with OPSS.MUNI 801.

.2 Install trunk protection prior to installation of tree supports if used.

3.6 Tree supports

.1 Install tree supports as indicated.

.2 Use single stake tree support for deciduous trees less than 3 m and evergreens less than 2 m.

.1 Place stake on prevailing wind side. Do not drive stake through the rootball.

.2 Drive stake minimum 1000 mm into undisturbed soil beneath roots. Ensure stake is secure, vertical and unsplit.

.3 Install ArborTie^{R} GREEN or approved alternate as per manufacturer's instructions.

.3 Use 3 stake tree supports for deciduous trees greater than 3 m and evergreens greater than 2 m.

.1 Use ArborTie^{R} GREEN or approved alternate for trees less than 75 mm in diameter.

3.7 Pruning

.1 After tree supports have been installed, prune all plants to remove dead and broken branches.

.2 Preserve the natural character of the plant. Do not remove the leader.

.3 Use clean, sharp tools and make cuts clean and flush without leaving stubs.

.4 Cut back to living tissue all cuts, scars and bruises and shape so as not to retain water.

3.8 Mulching

.1 Ensure soil settlement has been corrected prior to mulching.

.2 Spread mulch as indicated.

3.9 Maintenance during establishment period

.1 Perform following maintenance operations from time of planting to acceptance to Substantial Performance.

.1 Water to maintain soil moisture conditions for optimum establishment, growth and health of plant material without causing erosion.

.1 For evergreen plant material, water thoroughly in late fall prior to freeze-up to saturate soil around root system.

.2 Remove weeds monthly.

.3 Replace or respread damaged, missing or disturbed mulch.

.4 For non-mulched areas, cultivate as required to keep top layer of soil friable.

.5 Apply pesticides according to Federal, Provincial and Municipal regulations as and if required by the Consultant to control insects, fungus and disease. Obtain product approval from the Consultant prior to application.

.6 Remove dead or broken branches from plant material.

.7 Keep trunk protection and guy wires in proper repair and adjustment.

.8 Remove and replace dead plants and plants not in healthy growing condition. Make replacements in same manner as specified for original plantings.

3.10 Acceptance

.1 Acceptance of the plant material at its source does not preclude its rejection upon delivery to site or during planting operations.

.2 All plant material will be accepted by the Consultant when the entire project has reached Substantial Performance and the planting operation is complete, provided that the plant material exhibits healthy vigorous growth and is free from disease, insects and fungal organisms.

.3 All plant material installed less than ninety (90) days prior to frost will be reviewed for acceptance in the following spring, thirty (30) days after the start of the growing season, provided that acceptance conditions are fulfilled.

3.11 Maintenance during warranty period

.1 From time of acceptance by the Consultant to end of warranty period, perform following maintenance operations.

.1 Water to maintain soil moisture conditions for optimum growth and health of plant material without causing erosion.

.2 Reform damaged watering saucers.

.3 Remove weeds monthly.

.4 Replace or re-spread damaged, missing or disturbed mulch.

.5 For non-mulched areas, cultivate monthly to keep top layer of soil friable.

.6 Apply pesticides according to Federal, Provincial and Municipal regulations as and when required by the Consultant to control insects, fungus and disease. Obtain product approval from the Consultant prior to application.

.7 Apply fertilizer in early spring as indicated by soil test.

.8 Remove dead, broken or hazardous branches from plant material.

.9 Keep trunk protection and tree supports in proper repair and adjustment.

.10 Remove trunk protection, tree supports and level watering saucers at end of warranty period.

.11 Submit monthly written reports to the Consultant identifying:

.1 Maintenance work carried out.

.2 Development and condition of plant material.

.3 Preventative or corrective measures required which are outside Contractor's responsibility.

.12 An inspection of plant material will occur after the first year following Substantial Performance. Replacements may be required at that time depending on the extent of plant deficiencies noted. Plant replacements as soon as possible, during the proper planting season, according to accepted horticultural practices.

3.12 End of warranty

.1 Remove and replace dead plants and plants not in healthy growing condition. Make replacements in same manner as specified for original plantings.

.2 Remove trunk protection and tree supports.

.3 Adjust rodent protection, leave intact.

.4 Final inspection of plant material at the end of the warranty period may require extended warranties depending on the number of replacements required.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for maintenance holes and catch basin structures in accordance with OPSS.MUNI 407 and as amended by this section.

1.2 Related requirements

.1 Section 31 23 33 – Excavation Trenching and Backfilling

1.3 Reference standards

.1 ASTM International

.1 ASTM A48/A48M-03(2012), Standard Specification for Grey Iron Castings.

.2 ASTM A123/A123M-2012, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

.3 ASTM C117-13, Standard Test Method for Materials Finer than 75-mm (No. 200) Sieve in Mineral Aggregates by Washing.

.4 ASTM C136-06, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.5 ASTM C139-11, Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.

.6 ASTM C478M-13, Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric).

.7 ASTM D698-12, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft. lbf/ft^3 (600 kN-m/m^3)).

.2 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-8.1-88, Sieves, Testing, Woven Wire, Inch Series.

.2 CAN/CGSB-8.2-M88, Sieves, Testing, Woven Wire, Metric.

.3 CSA Group

.1 CSA A23.1/A23.2-09, Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete.

.2 CAN/CSA-A165 Series-04(R2009), CSA Standards on Concrete Masonry Units (Consists of A165.1, A165.2 and A165.3).

.3 CAN/CSA-A3000-08, Cementitious Materials Compendium (Consists of A3001, A3002, A3003, A3004 and A3005).

.4 CSA G30.18-09, Carbon Steel Bars for Concrete Reinforcement.

.4 Ontario Provincial Standard Specifications (OPSS)

.1 OPSS.MUNI 407-November 2020, Construction Specification For Maintenance Hole, Catch Basin, Ditch Inlet And Valve Chamber Installation.

1.4 Action and informational submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for maintenance holes and catch basin structures and include product characteristics, performance criteria, physical size, finish and limitations.

.4 Shop Drawings:

.1 Submit drawings stamped and signed by Professional Engineer registered or licensed in the province of Work.

1.5 Quality assurance

.1 Submit according to Section 01 45 00 – Quality Control.

.2 Testing Agency: Retain a Professional Engineer, registered in the Province of the work, to provide testing and inspection services for the work of this Section according to applicable codes, standards and Contract Documents.

.3 Certifications:

.1 Submit confirmation by the Testing Agency that materials and installation complies with the Contract Documents.

.4 Test Data:

.1 If requested by Consultant, submit test data verifying that specified requirements are being met. Test results may be from a previous testing program conducted on a system similar to that specified herein.

.5 Certifications:

.1 Submit, to the Testing Agency, the manufacturer's test data and certification at least four (4) weeks prior to beginning Work. Include manufacturer's drawings, information and shop drawings where pertinent.

.2 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.3 Manufacturer’s Instructions: submit manufacturer’s installation instructions and special handling criteria, installation sequence, and cleaning procedures.

1.6 Delivery, storage and handling

.1 Deliver, store and handle materials according to Section 01 65 00 – Product Delivery Requirements.

.2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials in dry location and according to manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect maintenance holes and catch basin structures from nicks, scratches, and blemishes.

.3 Replace defective or damaged materials with new.

.4 Develop and submit tot the Testing Agency a Construction Waste Management Plan related to Work of this Section.

.5 Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding, packaging materials as specified in Construction Waste Management Plan according to Section 01 74 00 – Cleaning and Waste Management.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Materials

.1 Cast-in-place concrete:

.1 According to Section 03 30 00 – Cast-in-Place Concrete.

.2 Cement: to CAN/CSA-A3001, Type GU.

.3 Concrete mix design to produce 21MPa minimum compressive strength at twenty (28) days and containing 25 mm maximum size coarse aggregate, with water/cement ratio to CSA A23.1

.1 Air entrainment to CSA A23.1.

.4 Supplementary cementing materials: with minimum 20 % GGBFS by mass of total cementitious materials to CAN/CSA-A3001.

.5 Concrete reinforcement: according to Section 03 20 00 – Concrete Reinforcing.

.2 Precast maintenance hole units: to ASTM C478M, circular or oval.

.1 Top sections eccentric cone or flat slab top type with opening offset for vertical ladder installation.

.3 Precast catch basin sections: to ASTM C139

.4 Joints: made watertight using rubber ring, bituminous compound, epoxy resin cement.

.5 Mortar:

.1 Aggregate: sand

.2 Masonry Cement: to CAN/CSA-A3002.

.6 Ladder rungs: to CSA G30.18, No.25M billet steel deformed bars, hot dipped galvanized to ASTM A123/A123M.

.1 Rungs to be safety pattern (drop step type).

.7 Adjusting rings: to ASTM C478M.

.8 Concrete Brick: to CAN/CSA-A165 Series.

.9 Drop maintenance hole pipe: same as sewer pipe.

.10 Galvanized iron sheet: approximately 2 mm thick.

.11 Steel gratings, I-beams and fasteners: as indicated.

.12 Frames, gratings, covers to dimensions as indicated and following requirements:

.1 Metal gratings and covers to bear evenly on frames.

.1 Frame with grating or cover to constitute one unit.

.2 Assemble and mark unit components before shipment.

.2 Gray iron castings: to ASTM A48/A48M, strength class 30B.

.3 Castings: coated with two applications of asphalt varnish

.4 Maintenance hole frames and covers: cover cast and complete with two (2) 25 mm square lifting holes to OPSS 407.

.5 Catch basin frames and covers: to OPSS 407.

.6 Size: 762 mm clear diameter.

.13 Granular bedding and backfill: according to Section 31 05 16 – Aggregates for Earthworks and following requirements:

.1 Crushed stone.

.2 Gradations to be within limits specified when tested to ASTM C136. Sieve sizes to CAN/CGSB-8.1.

.3 Concrete mixes and materials: according to Section 03 30 00 – Cast-in-Place Concrete.

.14 Unshrinkable fill: according to Section 31 23 33 – Excavating, Trenching and Backfilling.

3 Execution

3.1 Examination

.1 Verification of Conditions: Have the Testing Agency verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for maintenance holes and catch basin structures installation according to manufacturer's written instructions.

.1 Visually inspect substrate in presence of the Testing Agency.

.2 Inform the Testing Agency of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Testing Agency.

3.2 Excavation and backfill

.1 Excavate and backfill according to Section 31 23 33 – Excavating Trenching and Backfilling and as indicated.

.2 Obtain approval of the Testing Agency before installing maintenance holes or catch basins.

3.3 Concrete work

.1 Do concrete work according to Section 03 30 00 – Cast-in-Place Concrete.

.2 Place concrete reinforcement according to Section 03 30 00 – Cast-in-Place Concrete.

3.4 Installation

.1 Construct units according to details indicated, plumb and true to alignment and grade.

.2 Complete units as pipe laying progresses.

.1 Maximum of three (3) units behind point of pipe laying will be allowed.

.3 Dewater excavation to approval of the Testing Agency and remove soft and foreign material before placing concrete base.

.4 Cast bottom slabs directly on undisturbed ground.

.5 Set precast concrete base on 150 mm minimum of granular bedding compacted to 100 % maximum density to ASTM D698.

.6 Precast units:

.1 Set bottom section of precast unit in bed of cement mortar and bond to concrete slab or base.

.2 Make each successive joint watertight with the Testing Agency's approved rubber ring gaskets, bituminous compound, cement mortar, epoxy resin cement, or combination of these materials.

.3 Clean surplus mortar and joint compounds from interior surface of unit as work progresses.

.4 Plug lifting holes with precast concrete plugs set in cement mortar or mastic compound.

.7 For sewers:

.1 Place stub outlets and bulkheads at elevations and in positions indicated.

.2 Bench to provide smooth U-shaped channel.

.1 Side height of channel to be 0.75 times diameter of sewer.

.2 Slope adjacent floor at 1 in 20.

.3 Curve channels smoothly.

.4 Slope invert to establish sewer grade.

.8 Compact granular backfill to 95 % maximum density to ASTM D698.

.9 Place unshrinkable backfill according to Section 31 23 33 – Excavating, Trenching and Backfilling.

.10 Installing units in existing systems:

.1 Where a new unit is installed in existing run of pipe, ensure full support of existing pipe during installation, and carefully remove that portion of existing pipe to dimensions required and install new unit as specified.

.2 Make joints watertight between new unit and existing pipe.

.3 Where deemed expedient to maintain service around existing pipes and when systems constructed under this project are ready for

operation, complete installation with appropriate break-outs, removals, redirection of flows, blocking unused pipes or other necessary work.

.11 Place frame and cover on top section to elevation as indicated.

.1 If adjustment required use concrete ring.

.12 Clean units of debris and foreign materials.

.1 Remove fins and sharp projections.

.2 Prevent debris from entering system.

.13 Install safety platforms in maintenance holes having depth of 5 m or greater, as indicated. Space safety grates not more than 5 m apart. The platform will be located 2 m below the maintenance hole cover and 2.8 m above the maintenance hole invert.

3.5 Adjusting tops of existing units

.1 Remove existing gratings, frames and store for re-use at locations designated by the Testing Agency

.2 Sectional units:

.1 Raise or lower straight walled sectional units by adding or removing precast sections as required.

.2 Raise or lower tapered units by removing cone section, adding, removing, or substituting riser sections to obtain required elevation, then replace cone section.

.1 When amount of raise is less than 600 mm use standard maintenance hole brick, moduloc or grade rings.

.3 Monolithic units:

.1 Raise monolithic units by roughening existing top to ensure proper bond and extend to required elevation with cast-in-place concrete.

.2 Lower monolithic units with straight wall by removing concrete to elevation indicated for rebuilding.

.3 When monolithic units with tapered upper section are lowered more than 150 mm, remove concrete for entire depth of taper plus as much straight wall as necessary, then rebuild upper section to required elevation with cast-in-place concrete.

.4 Install additional maintenance hole ladder rungs in adjusted portion of units as required.

.5 Re-use existing gratings, frames.

.6 Re-set gratings and frames to required elevation on not more than 4 courses of brick.

.1 Make brick joints and join brick to frame with cement mortar, parge and trowel smooth.

.2 Re-set gratings and frames to required elevation on full bed of cement mortar, parge and trowel smooth.

3.6 Sealing over existing units

.1 Cut galvanized iron sheet to extend 50 mm beyond opening of existing maintenance hole or catch basin grating.

.1 Center iron sheet over existing grating and spot or stitch weld to grating.

.2 Fill with cast-in-place concrete.

3.7 Field quality control

.1 Leakage Test:

.1 Install watertight plugs or seals on inlets and outlets of each new sanitary sewer maintenance hole and fill maintenance hole with water.

.2 Leakage not to exceed 0.3 % per hour of volume of maintenance hole.

.3 If permissible leakage is exceeded, correct defects.

.4 Repeat until approved by the Testing Agency.

.5 The Testing Agency will issue a Test Certificate for each maintenance hole passing test.

3.8 Cleaning

.1 Progress Cleaning: clean according to Section 01 74 00 – Cleaning and Waste Management.

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment according to Section 01 74 00 – Cleaning and Waste Management.

.3 Waste Management: separate waste materials for reuse and recycling according to Section 01 74 00 – Cleaning and Waste Management.

.1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

End of section

1 General

1.1 Section includes

.1 This section specifies requirements for supplying and installing gravity sewer for buried wastewater conveyance in accordance with OPSS.MUNI 410 and as amended by this section. Most stringent requirements will govern.

.2 The Contractor must provide the necessary submittals and ensure the proper registration of piping systems and system components as required by authorities having jurisdiction, local municipality, AWWA, API, ASME, TSSA and CRN requirements.

1.2 Related requirements

.1 Section 31 05 16 – Aggregates for Earthwork

.2 Section 31 23 33 – Excavating, Trenching and Backfilling

1.3 Reference standards

.1 American National Standards Institute/American Water Works Association (ANSI/AWWA)

.1 ANSI/AWWA C906-15 Polyethylene (PE) Pressure Pipe and Fittings, 4 in. through 65 in. (100 mm through 1,650 mm), for Waterworks

.2 Latest version of the American Society for Testing and Materials (ASTM) International Standards:

.1 ASTM F1759 – 97 (2010) Standard Practice for Design of High-Density Polyethylene (HDPE) Manholes for Subsurface Applications

.2 ASTM F714-13 Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

.3 ASTM F 2620-13 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

.4 ASTM D 2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

.5 ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

.6 ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

.7 ASTM D3035 -15 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

.8 ASTM C117-13, Standard Test Method for Materials Finer than 75-mm (No. 200) Sieve in Mineral Aggregates by Washing

.9 ASTM C136-06, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

.10 ASTM C139-11, Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes.

.11 ASTM C478M-13, Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric).

.12 ASTM D698-12, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft. lbf/ft^3 (600 kN-m/m^3)).

.13 ASTM C311 and ASTM 618 (Fly Ash)

.3 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-8.1-88, Sieves, Testing, Woven Wire, Inch Series.

.2 CAN/CGSB-8.2-M88, Sieves, Testing, Woven Wire, Metric.

.4 Concrete Pipe

.1 CAN/CSA-A 257.2 – Reinforced Concrete Culvert, Storm Drain and Sewer Pipes; Strength Classification 40 D or 50 D or 65 D or 100 D or 140 D.

.1 Minimum 335 kg/m^3 without Fly Ash

.1 Minimum 285 kg/m^3 with Fly Ash

.1 Water to Cementitious ratio Not over 0.49

.5 Portland Cement to CAN/CSA-A5 or Blended Hydraulic Cement to CAN/CSA-A362 or supplementary cementing material to the requirements of CAN/CSA-A23.5

.6 Fly Ash CAN/CSA-A23:

.1 Loss on Ignition: Maximum 3 %

.2 Water Requirement: Maximum 100 % of control

.3 Ratio Percent CaO/Fe_2O_3: Maximum 1.5

.4 or test cement fly ash mix according to ASTM C1012. Mix: Equal to or better than ASTM C150, Type II cement (51 kg/m^3 minimum, 95 kg/m^3 maximum).

.7 CAN/CSA A23.5 Ground Granulated Blast – Furnace slag with the exception of the requirements for “Reactivity with Cement Alkalies”

.8 CAN/CSA 23.1 Physical and Chemical requirements Silica Fume with the exception of the requirements for “Reactivity with Cement Alkalies”

.9 CAN/CSA 23.1 Aggregates : Concrete Materials and Methods of Concrete Construction except that the grading requirements does not apply

.10 CAN/CSA A266.1 Admixtures– Air Entraining Admixture for Concrete; or CAN/CSA-A266.2 – Chemical Admixtures for Concrete.

.11 CAN/CSA-A23.1 Water

.12 Reinforcement

.1 Wire according to CSA Standards:

.1 G30.3 – Cold Drawn Wire for Concrete Reinforcement; or

.2 G30.14 – Deformed Steel Wire for Concrete Reinforcement.

.2 Wire Fabric according to CSA Standards:

.1 G30.5 – Welded Steel Wire Fabric for Concrete Reinforcement; or

.2 G30.15 – Welded Deformed Steel Wire Fabric for Concrete Reinforcement

.3 Deformed Bars according to CSA Standards:

.1 G30.12 M – Billet – Steel Bars for Concrete Reinforcement; or

.2 G30.16 M – Welded Low Alloy Steel Deformed Bars for Concrete Reinforcement.

.13 CAN/CSA-A257.3. Joints - Captive gasket in groove.

.14 CAN/CSA-A257.3. Rubber Gaskets

.15 Source Quality Control Testing

.1 Structural strength –D- Load 0.3 mm crack, compressive strength and absorption according to CAN/CSA A257.0 and A257.2

.2 Voids: Longitudinally sawcut one pipe from each 100 lengths of pipe manufactured in half with saw that will not damage the concrete or reinforcing steel. Inspect for voids adjacent to circumferential bars. Voids will be considered continuous if a 1/16 in. diameter pin can be inserted 1/4 in. deep. If voids exist adjacent to more than 10 % of the circumferential bars, test two additional pipes. If either of the two pipes fail, the entire 100 lengths will be rejected.

.16 ASME B31.3-10, Process Piping.

.17 CSA International

.1 CSA B1800-11, Thermoplastic Non-pressure Pipe Compendium.

.1 CSA B182.1-11, Plastic Drain and Sewer Pipe and Pipe Fittings.

.2 CSA B182.2-11, PSM Type Polyvinylchloride PVC Sewer Pipe and Fittings.

.18 Latest edition of Ontario Provincial Standards Specifications (OPSS) and local municipal specifications:

.1 OPSS.MUNI 401 Construction Specification for Trenching, Backfilling and Compacting.

.2 OPSS.MUNI 409 Construction Specification for closed-circuit television inspection of pipelines.

.3 OPSS.MUNI 410 Construction Specification for Installation of Pipe Sewers in Open Cut.

.4 OPSS.MUNI 501 Construction Specification for Compacting.

.5 OPSS MUNI.904 Construction Specification for Concrete Structures.

.6 OPSS.MUNI 1010 Material Specification for Aggregates - Granular A, B, M and Select Subgrade Material.

.19 Latest edition of Ontario Provincial Standards Drawings (OPSD) as indicated on Drawings.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data:

.1 Submit to the Testing Agency the manufacturer's instructions, printed product literature and data sheets for pipes and casing spaces include product characteristics, performance criteria, physical size, finish and limitations.

.2 Submit manufacturer’s test data and certification at least four (4) weeks prior to beginning work.

.3 Submit one (1) copy of manufacturer’s installation instructions.

.4 Samples:

.1 Inform the Testing Agency at least four (4) weeks prior to beginning Work, of proposed source of bedding materials and provide access for sampling.

.5 Certificates:

.1 Certification to be marked on pipe.

.6 Test and Evaluation Reports:

.1 Submit manufacturer's test data and certification four (4) weeks minimum before beginning Work.

1.5 Quality assurance

.1 Testing Agency: Retain a Professional Engineer, registered in the Province of the work, to provide testing and inspection services for the

work of this Section according to applicable codes, standards and Contract Documents.

.2 Certifications:

.1 Submit confirmation by the Testing Agency that materials and installation complies with the Contract Documents.

.3 Test Data:

.1 If requested by Consultant, submit test data verifying that specified requirements are being met. Test results may be from a previous testing program conducted on a system similar to that specified herein.

.4 Deliver, store and handle materials according to Section 01 65 00 – Product Delivery Requirements.

.5 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.

.6 Storage and Handling Requirements:

.1 Store materials according to manufacturer's recommendations.

.2 Store and protect pipes from damage.

.3 Replace defective or damaged materials with new.

.4 Provide quality control for compaction of various materials according to OPSS 501 Table 1 with the following modifications:

.1 Part 3 (III) lot size to be every lift (max 0.6 m), 30 m maximum length.

.7 Demonstrate tracer wire continuity post backfilling in the presence of the Testing Agency.

1.6 Waste management and disposal

.1 Separate waste materials for reuse and recycling according to Section 01 74 00 – Cleaning and Waste Management.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material for recycling according to Waste Management Plan.

.4 Separate for reuse and recycling and place in designated containers according to Waste Management Plan.

.5 Divert unused metal materials from landfill to metal recycling facility for disposal approved by the Testing Agency

.6 Divert unused concrete materials from landfill to local facility as approved by the Testing Agency.

.7 Divert unused aggregate materials from landfill to facility for reuse as approved by the Testing Agency.

.8 Place materials defined as hazardous or toxic in designated containers.

.9 Handle and dispose of hazardous materials according to the CEPA, Regional and Municipal regulations.

.10 Fold up metal banding, flatten and place in designated area for recycling.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Approved manufacturers and products

.1 Provide manufactures and products for Work of this section in accordance with latest Regional Municipality of Durham Works Departments list of approved manufactures' products for sanitary sewers and forcemains: https://www.roadauthority.com/ASP/mpl/mpl.asp?MPIShortName=Durham+MPL

2.3 Pipe materials

.1 Refer to drawings for pipe materials. No alternative materials will be allowed.

.2 The following pipe materials are permitted to be used for sanitary sewers:

.1 Concrete

.2 Polyvinylchloride

.3 Polyethylene

.3 The following pipe materials are permitted to be used for storm sewers:

.1 Polyvinylchloride

.2 Concrete

.3 Profile Rib pipe

2.4 Casing spacers / centralizers

.1 High Density Polyethylene Casing Spacers:

.1 Yield strength 3,625 psi as per ASTM D638

.2 Tensile strength 2,900 psi as per ASTM D638

.3 Elongation at break 800 % as per ASTM D638

.4 Hardness (D) = 65 as be ASTM D2240

.5 Dielectric strength 37 Kv/mm as per ASTM 149/64.

.2 Type F/G (Medium) by Raci Spacers Inc, or approved alternate.

.3 Select sizing to suit forcemain pipe outside diameter and carrier pipe inside diameter.

2.5 Pipe bedding and surround materials

.1 Granular material to Section 31 05 16 – Aggregate for Earthwork and following requirements:

.1 Granular ‘A’ maximum size 19.0 mm

.2 Granular ‘B’ Type I, maximum size 26.5 mm.

.3 Granular ‘M’ maximum size 19.0 mm.

.2 Flexible Pipe

.1 Embedment material (bedding and cover) from invert of trench to min 300 mm over the pope using 19 mm crusher run limestone or Granular ‘A’

.2 Provide 19 mm crusher run limestone or HL8 blend clear crushed stone for extra depth bedding.

2.6 Backfill material

.1 Type 3, according to Section 31 23 33 – Excavating, Trenching and Backfilling.

.2 Unshrinkable fill: to Section 31 23 33 – Excavating, Trenching and Backfilling.

2.7 Tracer wire

.1 Provide tracer wire along all piping according to OPSS.MUNI 441.

3 Execution

3.1 Examination

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for sewer pipe installation according to manufacturer's written instructions.

.1 Visually inspect substrate in presence of the Testing Agency.

.2 Inform the Testing Agency of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from the Testing Agency.

3.2 Preparation

.1 Clean pipes and fittings of debris and water before installation, and remove defective materials from site to approval of the Testing Agency.

3.3 Trenching

.1 Do trenching Work according to Section 31 23 33 – Excavating, Trenching and Backfilling.

.2 Protect trench from contents of sewer or sewer connection.

.3 Trench alignment and depth require approval of the Testing Agency prior to placing bedding material and pipe.

3.4 Granular bedding

.1 Place bedding in unfrozen condition.

.2 Place granular bedding materials in uniform layer(s) not exceeding 150 mm compacted thickness.

.3 Shape bed true to grade and to provide continuous, uniform bearing surface for pipe.

.1 Do not use blocks when bedding pipe.

.4 Shape transverse depressions as required to suit joints.

.5 Compact each layer full width of bed to at least 98 % maximum density to ASTM D698

.6 Fill excavation below bottom of specified bedding adjacent to manholes or structures with compacted bedding material.

3.5 Installation

.1 Fabricate and install pressure piping according to TSSA.

.2 Lay and join pipes according to manufacturer's recommendations and to approval of the Testing Agency.

.3 Handle pipe using methods approved by the Testing Agency.

.1 Do not use chains or cables passed through rigid pipe bore so that weight of pipe bears upon pipe ends.

.4 Lay pipes on prepared bed, true to line and grade, with pipe invert smooth and free of sags or high points.

.1 Ensure barrel of each pipe is in contact with shaped bed throughout its full length.

.5 Begin laying at outlet and proceed in upstream direction with socket ends of pipe facing upgrade.

.6 Joint deflection permitted within limits recommended by pipe manufacturer.

.7 Water to flow through pipe during construction, only as permitted by the Testing Agency.

.8 If Work is suspended, install removable watertight bulkhead at open end of last pipe laid to prevent entry of foreign materials.

.9 Install plastic pipe and fittings according to CSA B182.11.

.10 Pipe jointing:

.1 All joints to be by the butt fusion method as described by ASTM F2620 and all butt fusion welds performed with hydraulically operated butt fusion equipment recorded using a McElroy Manufacturing DataLogger, or approved alternate. Ensure the fabricator maintains records of the temperature, pressure, and graph of the fusion cycle for a minimum of three (3) years.

.11 If stoppage of work occurs, block pipes as directed by the Testing Agency to prevent creep during down time.

.12 Cut pipes as required for special inserts, fittings or closure pieces as recommended by pipe manufacturer, without damaging pipe or its coating and to leave smooth end at right angles to axis of pipe.

.13 Make watertight connections to Buried Structures.

3.6 Pipe surround

.1 Place surround material in unfrozen condition.

.2 Upon completion of pipe laying, and after the Testing Agency has inspected pipe joints, surround and cover pipes as indicated.

.3 Leave joints and fittings exposed until field testing is completed.

.4 Place layers uniformly and simultaneously on each side of pipe.

.5 Compact each layer from pipe invert to mid height of pipe to at least 98 % maximum density to ASTM D698.

.6 Compact each layer from mid height of pipe to underside of backfill to at least 95% maximum density to ASTM D698.

.7 If field test results are acceptable to the Testing Agency, place surround material at pipe joints.

3.7 Backfill

.1 Place backfill material in unfrozen condition.

.2 Place backfill material, above pipe surround in uniform layers not exceeding 150 mm compacted thickness up to grades as indicated.

.3 Under paving, granular roads and granular storage / parking areas and walks, compact backfill to at least 95 % maximum density to ASTM D698.

.1 In other areas, compact to at least 90 % maximum density to ASTM D698.

.4 Place unshrinkable fill specified according to Section 31 23 33 – Excavating, Trenching and Backfilling.

3.8 Field quality control

.1 Perform tests according to OPSS.PROV 441.

.2 Provide the supply of water necessary to fill and complete all testing to the satisfaction of the Testing Agency.

.3 Repair or replace pipe, pipe joint or bedding found defective.

.4 Provide quality control for compaction of various materials according to OPSS 501 Table 1.

.5 Demonstrate tracer wire continuity post backfilling in the presence of the Testing Agency.

.6 Provide labour, equipment and materials required for Testing Agency to perform hydrostatic and leakage tests hereinafter described.

.1 Notify the Testing Agency at least forty eight (48) hours in advance of proposed tests.

.1 Perform tests in presence of the Testing Agency.

.2 Upon completion of pipe laying and after the Testing Agency has inspected Work in place, surround and cover pipes between joints with approved granular material placed as directed by the Testing Agency.

.3 Leave joints and fittings exposed.

.4 If testing is done during freezing weather, joints and fittings from freezing.

.5 Expel air from main by slowly filling main with potable water.

.6 Thoroughly examine exposed parts and correct for leakage as necessary.

.7 Ensure hydrostatic test pressure is 150 psi for forcemains and 5 psi for gravity sewers.

.8 Apply hydrostatic test pressure based on elevation of lowest point in main and corrected to elevation of test gauge, for period of two (2) hours.

.9 Examine exposed pipe, joints, fittings and appurtenances while system is under pressure.

.10 Remove joints, fittings and appurtenances found defective and replace with new sound material and make watertight.

.11 Repeat hydrostatic test until defects have been corrected.

.12 Apply leakage test pressure to design working pressure as directed by the Testing Agency after complete backfilling of trench, based on elevation of lowest point in main and corrected to elevation of gauge, for period of two (2) hours.

.13 Define leakage as amount of water supplied from water storage tank in order to maintain test pressure for two (2) hours.

.14 Do not exceed allowable leakage of 2.22 L/mm of pipe, diameter per 1,000 m of pipe/day.

.15 Locate and repair defects if leakage is greater than amount specified.

.16 Repeat test until leakage is within specified allowance for full length of water main.

.7 Repair or replace pipe, pipe joint or bedding found defective.

.8 If directed by the Testing Agency, draw tapered plug with diameter of 50 mm less than nominal pipe diameter through sewer to ensure that pipe is free of obstruction.

.9 Remove foreign material from sewers and related appurtenances by flushing with water.

.10 CCTV Inspections for all gravity sewer pipes:

.1 Carry out inspection of installed sewers by television camera as per OPSS 409.

.2 Provide means of access to permit the Testing Agency to do additional inspections, if requested.

3.9 Cleaning

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment.

End of section

1 General

1.1 Section includes

.1 Labour, Products, equipment and services necessary for service, domestic water distribution mains Work according to the Contract Documents.

1.2 Related requirements

.1 Section 31 23 33 – Excavating, Trenching and Backfilling

1.3 Reference standards

.1 American National Standards Institute/American Water Works Association (ANSI/AWWA)

.1 ANSI/AWWA B300-10, Standard for Hypochlorites.

.2 ANSI/AWWA B301-10, Standard for Liquid Chlorine.

.3 ANSI/AWWA B303-10, Standard for Sodium Chlorite.

.4 ANSI/AWWA C111/A21.11-07, American National Standard for Rubber-Gasket Joints for Ductile-Iron and Fittings.

.5 ANSI/AWWA C110/A21.10-08, American National Standard for Ductile-Iron and Grey Iron Fittings for Water.

.6 ANSI/AWWA C651-05, Standard for Disinfecting Water Mains.

.7 ANSI/AWWA C800-05, Standard for Underground Service Line Valves and Fittings.

.8 ANSI/AWWA C900-07, Standard for Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 in. through 12 in. (100 mm - 300 mm), for Water Transmission and Distribution.

.9 AWWA C901-08 Polyethylene (PE) Pressure Pipe and Tubing, ½ in. (13 mm) Through 3 In. (76 mm), for Water Service.

.2 ASTM International

.1 ASTM A307-10, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile.

.2 ASTM B88M-05(2011), Standard Specification for Seamless Copper Water Tube Metric.

.3 ASTM C117-04, Standard Test Methods for Material Finer Than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing.

.4 ASTM C136-06, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.

.5 ASTM D698-07e1, Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft. lbf/ft^3 (600 kN-m/m^3)).

.6 ASTM F714-13 Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

.7 ASTM F 2620-13 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.

.8 ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

.3 American Water Works Association (AWWA)/Manual of Practice

.1 AWWA M17-2006, Installation, Field Testing, and Maintenance of Fire Hydrants.

.4 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-8.2-M88, Sieves, Testing, Woven Wire, Metric.

.5 CSA International

.1 CAN/CSA-B137 Series-09, Thermoplastic Pressure Piping Compendium. (Consists of B137.0, B137.1, B137.2, B137.3, B137.4, B137.4.1, B137.5, B137.6, B137.8, B137.9, B137.10, B137.11 and B137.12).

.1 CAN/CSA-B137.3-09, Rigid Polyvinyl Chloride (PVC) Pipe for Pressure Applications.

.2 The moulding and extrusion material used to manufacture polyethylene fittings to be polyethylene according to requirements of CSA B137.1 for fittings less than 100 mm diameter.

.6 The Master Painters Institute (MPI)

.1 Architectural Painting Specification Manual - current edition.

.7 Underwriters' Laboratories of Canada (ULC)

.1 CAN/ULC-S520-07, Standard for Fire Hydrants.

.2 CAN/ULC-S543-09, Standard for Internal-Lug, Quick Connect Couplings for Fire Hose.

.8 Latest edition of Ontario Provincial Standard Specification (OPSS):

.1 OPSS.MUNI 501 Construction Specification for Compacting.

.2 OPSS.MUNI 1010 Material Specification for Aggregates - Granular A, B, M and Select Subgrade Material.

.3 OPSS.MUNI 441 - Construction Specification for Watermain Installation in Open Cut.

.4 OPSS.MUNI 442- Construction Specification for Corrosion Protection of New and Existing Watermains and Fittings.

1.4 Submittals

.1 Submit according to Section 01 33 00 – Submittal Procedures.

.2 Sustainable Design: Submit the below completed forms demonstrating compliance with Section 01 81 13 – Sustainable Design Criteria:

.1 APPENDIX-B to Section 01 81 13 titled ‘LEED v4 Material Reporting Form- Low Emitting’

.2 APPENDIX-C to Section 01 81 13 titled ‘LEED v4 Material Reporting Form’

.3 Product Data:

.1 Submit manufacturer's instructions, printed product literature and data sheets for distribution piping materials, meter chamber, backflow prevention chamber, and detector valve chamber and associated piping, valves, backflow preventors, mechanically restrained joints and include product characteristics, performance criteria, physical size, finish and limitations at least four (4) weeks prior to beginning work.

.2 Pipe certification to be on pipe.

.4 Submit record drawings, including directions for operating valves, list of equipment required to operate valves, and details of pipe material within fifteen (15) days of completion of Work.

.1 Include top of pipe, horizontal location of fittings and type, valves, and valve boxes.

.5 Operation and Maintenance Data: submit operation and maintenance data for pipe, mechanically restrained joints, valves, valve boxes and hydrants for incorporation into manual within fifteen (15) days of completion of Work.

.6 Submit all results of pressure testing, flushing and disinfection of water distributions systems as per the requirements of Part 3 within fifteen (15) days of completion of Work.

1.5 Delivery, storage and handling

.1 Deliver, store and handle materials according to Section with manufacturer's written instructions and Section 01 65 00 – Product Delivery Requirements.

.2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.

.3 Storage and Handling Requirements:

.1 Store materials off ground and according to manufacturer's recommendations in clean, dry, well-ventilated area.

.2 Store and protect water distribution piping from nicks, scratches, and blemishes.

.3 Replace defective or damaged materials with new.

1.6 Waste management and disposal

.1 Separate waste materials for reuse and recycling according to Section 01 74 00 – Cleaning and Waste Management.

.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material for recycling.

.4 Separate for reuse and recycling and place in designated containers.

.5 Divert unused metal materials from landfill to metal recycling facility for disposal approved by Owner.

.6 Divert unused concrete materials from landfill to local facility as approved by Owner.

.7 Divert unused aggregate materials from landfill to facility for reuse as approved by Owner.

.8 Place materials defined as hazardous or toxic in designated containers.

.9 Handle and dispose of hazardous materials according to the CEPA, TDGA, Regional and Municipal regulations.

.10 Fold up metal banding, flatten and place in designated area for recycling.

2 Products

2.1 Materials – sustainable design

.1 Refer to Section 01 81 13 – Sustainable Design Criteria for LEED material requirements.

2.2 Approved manufacturers and products

.1 Provide manufactures and products for Work of this section in accordance with latest Regional Municipality of Durham Works Departments list of approved manufactures' products for sanitary sewers and forcemains: https://www.roadauthority.com/ASP/mpl/mpl.asp?MPIShortName=Durham+MPL

2.3 Pipe, joints and fittings

.1 Except if specified on the Contract Drawings, pipe 65 mm dia and smaller, Type K, soft seamless copper tube according to ASTM B88

.1 Wrought copper alloy, solder joint (lead free) pressure type according to ANSI/ASME B16.22.

.2 Dielectric union at connection between copper tubing and cast iron or ductile iron piping.

.3 Copper tubing joints: compression type suitable for 1 MPa working pressure.

2.4 Valves and valve boxes

.1 Valves to open counter clockwise

.1 Water service box as per OPSS Standards.

2.5 Pipe bedding and surround material

.1 Granular material to: Section 31 23 33 – Excavating, Trenching and Backfilling and following requirements:

.1 Granular 'A'

2.6 Backfill material

.1 Granular B Type 1 as per Section 31 23 33 – Excavating, Trenching and Backfilling.

2.7 Cathodic protection

.1 According to OPSS 442 for all metallic pipe, appurtenances and fittings.

2.8 Backflow prevention valves

.1 Backflow Prevention Valves and Chambers to Region of Durham Standards.

2.9 Water meter and chamber

.1 Water Meter and Chamber to Region of Durham standards.

2.10 Detector assembly and chamber

.1 Detector Assembly and Chamber to Region of Durham standards.

3 Execution

3.1 Examination

.1 Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for distribution piping installation according to manufacturer's written instructions.

.1 Visually inspect substrate in presence of the Consultant.

.2 Inform the Consultant of unacceptable conditions immediately upon discovery.

.3 Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from the Consultant.

3.2 Preparation

.1 Clean pipes, fittings, valves, and appurtenances of accumulated debris and water before installation.

.1 Inspect materials for defects to approval of the Consultant.

.2 Remove defective materials from site as directed by the Consultant.

3.3 Trenching

.1 Do trenching work according to Section 31 23 33 – Excavating, Trenching and Backfilling.

.2 Ensure trench depth allows coverage over pipe of 1.8 m.

.3 Trench alignment and depth require the Consultant's approval prior to placing bedding material and pipe.

3.4 Granular bedding

.1 Place granular bedding material in uniform layers not exceeding 150 mm compacted thickness to depth of 150 mm below bottom of pipe.

.2 Do not place material in frozen condition.

.3 Shape bed true to grade to provide continuous uniform bearing surface for pipe.

.4 Shape transverse depressions in bedding as required to suit joints.

.5 Compact each layer full width of bed to 98 % maximum density to ASTM D698.

.6 Fill authorized or unauthorized excavation below design elevation of bottom of specified bedding according to Section 31 23 33 – Excavating, Trenching and Backfilling.

3.5 Pipe installation

.1 The minimum burial depth for all watermains is 1.8m in all areas.

.2 Handle pipe by methods recommended by pipe manufacturer. Do not use chains or cables passed through pipe bore so that weight of pipe bears on pipe ends.

.3 Lay pipes on prepared bed, true to line and grade.

.4 Ensure barrel of each pipe is in contact with shaped bed throughout its full length.

.5 Take up and replace defective pipe.

.6 Correct pipe which is not in true alignment or grade or pipe which shows differential settlement after installation greater than 10 mm in 3 m.

.7 Face socket ends of pipe in direction of laying. For mains on grade, face socket ends up-grade.

.8 Do not exceed permissible deflection at joints as recommended by pipe manufacturer.

.9 Keep jointing materials and installed pipe free of dirt and water and other foreign materials.

.10 If work is stopped, install a removable watertight bulkhead at open end of last pipe laid to prevent entry of foreign materials.

.11 Position and join pipes with equipment and methods approved by the Consultant.

.12 Cut pipes in approved manner as recommended by pipe manufacturer, without damaging pipe or its coating and to leave smooth end at right angles to axis of pipe.

.13 Align pipes before jointing.

.14 Install mechanical restrainers at each and every pipe joint.

.15 Complete each joint before laying next length of pipe.

.16 Minimize deflection after joint has been made.

.17 Apply sufficient pressure in making joints to ensure that joint is completed to manufacturer's recommendations.

.18 Ensure each completed joint is mechanically restrained and approved by the Consultant.

.19 If stoppage of work occurs, block pipes in an approved manner to prevent creep during down time.

.20 Do not lay pipe on frozen bedding.

.21 Do hydrostatic and leakage test and air leakage test as described in part 3.10 and have results approved by the Consultant before surrounding and covering joints and fittings with granular material.

.22 Backfill remainder of trench.

3.6 Valve installation

.1 Install valves to manufacturer's recommendations at locations as indicated.

.2 Support valves located in valve boxes and valve chambers by means of bedding same as adjacent pipe and concrete blocking, respectively. Valves not to be supported by the pipe.

.3 Install underground post-type indicator valves as indicated.

.4 Install Chambers as indicated.

3.7 Field quality control

.1 Preform tests according to NFPA 801 and OPSS 441.

.2 Repair or replace pipe, pipe joint or bedding found defective.

.3 Provide quality control for compaction of various materials according to OPSS 501 Table 1.

.4 Coordinate inspection of pipes such that the Consultant and /or Owner to witness that all joints have been installed with mechanical joint restraints.

.5 Provide labour, equipment and materials, including water to fill and test the pipes as required to perform hydrostatic and leakage tests hereinafter described.

.1 Notify the Consultant at least twenty four (24) hours in advance of proposed tests.

.1 Perform tests in presence of the Consultant.

.2 Upon completion of pipe laying and after the Consultant has inspected Work in place, surround and cover pipes between joints

with approved granular material placed as directed by the Consultant.

.3 If testing is done during freezing weather, protect joints and fittings from freezing.

.4 Expel air from main by slowly filling main with potable water.

.5 Thoroughly examine exposed parts and correct for leakage as necessary.

.6 Test hydrostatic test pressure at 150 psi for service water pipes.

.7 Apply hydrostatic test pressure based on elevation of lowest point in main and corrected to elevation of test gauge, for period of two (2) hours.

.8 Examine exposed pipe, joints, fittings and appurtenances while system is under pressure.

.9 Remove joints, fittings and appurtenances found defective and replace with new sound material and make watertight.

.10 Repeat hydrostatic test until defects have been corrected.

.11 Apply leakage test pressure to design working pressure as directed by the Consultant after complete backfilling of trench, based on elevation of lowest point in main and corrected to elevation of gauge, for period of two (2) hours.

.12 Define leakage as amount of water supplied from water storage tank in order to maintain test pressure for two (2) hours.

.13 Do not exceed allowable leakage of 2.22 L/mm of pipe, diameter per 1,000 m of pipe/day.

.14 Locate and repair defects if leakage is greater than amount specified.

.15 Repeat test until leakage is within specified allowance for full length of water main.

3.8 Pipe surround

.1 Upon completion of pipe laying and after the Consultant has inspected Work in place, surround and cover pipes as indicated.

.2 Hand place surround material in uniform layers not exceeding 150 mm compacted thickness as indicated.

.3 Place layers uniformly and simultaneously on each side of pipe.

.4 Do not place material in frozen condition.

.5 Compact each layer from pipe invert to mid height of pipe to at least 98 % maximum density to ASTM D698.

.6 Compact each layer from mid height of pipe to underside of backfill to at least 95 % maximum density to ASTM D698.

3.9 Backfill

.1 Place backfill material, above pipe surround, in uniform layers not exceeding 150 mm compacted thickness up to grades as indicated.

.2 Do not place backfill in frozen condition.

.3 Under paving, granular storage / parking areas and walks, compact backfill to at least 95 % maximum density to ASTM D698.

3.10 Flushing and disinfecting

.1 Watermains require flushing and disinfection.

.2 Flushing and disinfecting operations:

.1 Notify Consultant at least four (4) days in advance of proposed date when disinfecting operations will begin.

.2 Complete according to ANSI/AWWA 651 and OPSS 441.

.3 Provide supply of water to fill and test the piping.

.3 Flush water mains through available outlets with a sufficient flow of potable water to produce velocity of 1.5 m/s, within pipe for minimum ten (10) minutes, or until foreign materials have been removed and flushed water is clear.

.4 Flushing flows as follows:

Pipe Size NPS	Flow (L/s) Minimum
6 and below	38
8	75
10	115

12	150

.5 Provide connections and pumps for flushing as required.

.6 Open and close valves, hydrants and service connections to ensure thorough flushing.

.7 When flushing has been completed to the Consultant approval, introduce strong solution of chlorine as approved by the Consultant into water main and ensure that it is distributed throughout entire system.

.8 Rate of chlorine application to be proportional to rate of water entering pipe.

.9 Chlorine application to be close to point of filling watermain and to occur at same time.

.10 Operate valves, hydrants and appurtenances while main contains chlorine solution.

.11 Flush line to remove chlorine solution after twenty four (24) hours.

.12 Measure chlorine residuals at extreme end of pipe-line being tested.

.13 Perform bacteriological tests on water main after chlorine solution has been flushed out.

.1 Take samples daily for minimum of two (2) days.

.2 Should contamination remain or recur during this period, repeat disinfecting procedure.

.3 Specialist contractor to submit certified copy of test results.

.14 Take water samples at service connections, in suitable sequence, to test for chlorine residual.

.15 After adequate chlorine residual not less than 50 ppm has been obtained leave system charged with chlorine solution for twenty four (24) hours.

.1 After twenty four (24) hours, take further samples to ensure that there is still not less than 10 ppm of chlorine residual remaining throughout system.

3.11 Surface restoration

.1 After installing and backfilling over water mains, restore surface to original condition as directed by the Consultant.

3.12 Cleaning

.1 Leave Work area clean at end of each day.

.2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment.

End of section