SPECIFICATIONS

CITY OF TORONTO

Mount Dennis Childcare Centre

1234 Weston Road
Toronto, Ontario

Volume 2

Divisions 20-33

ISSUED FOR TENDER

January 17th, 2020

Coolearth Architecture Inc.
& CS&P Architects Inc.
Project No. 17026

Design Discipline

Documents prepared by the respective Consultants are designated by the following discipline symbols:

- Owner (O)
- Architect (A)
- Civil Consultant (C)
- Commissioning Consultant (COMM)
- Electrical Consultant (E)
- Landscape Consultant (L)
- Mechanical Consultant (M)
- Structural Consultant (S)
- Shoring Consultant (SH)

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PART 1 - GENERAL

1.1 Reference Sections

.1 These General Provisions apply to all sections in this Division.

.2 Conform to General Conditions, Supplementary General Conditions and Division 1, General Requirements.

1.2 Intent

.1 Provide all operations, materials and methods indicated on the drawings and/or specifications, including all labour and equipment as required for a complete mechanical installation.

.2 The contractor shall be responsible for the entire system including the provision of antifreezes for the entire system including the geothermal ground exchanger.

1.3 Definitions

.1 "Provide" means to supply and install the products and services specified.

.2 "The Work" means the total construction required by the Contract Documents and includes all labour, products and services.

.3 "Products" means all material, machinery, equipment and fixtures forming the completed Work as required by the Contract Documents.

.4 "Submit" means submit item requested to the Consultant for review.

.5 "Owner" means City of Toronto.

1.4 Acceptable Materials

.1 Bidders shall note that this is a Base Bid Specification. Products specified or shown on drawings by brand name or catalogue number and/or by the name of the manufacturer or supplier shall form the basis of the bid.

.2 If bidders wish to use alternate equipment, the equipment equipment performance, layout, size must conform to the base bid products.

.3 Owner reserves the right to accept or reject any or all the alternate products proposed by the bidders.

1.5 Governing Authorities and Approved Agencies

.1 Abbreviations with respect to governmental authorities, testing agencies, technical societies, and approval agencies are as listed below:

AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials

AWWA	American Water Works Association
BOCA	Building Officials Code Administrators
CEMA	Canadian Electrical Manufacturers Association
CGA	Canadian Gas Association
CSA	Canadian Standards Association
FM	Factory Mutual
IAO	Insurer's Advisory Organization
NBC	National Building Code
NBFU	National Board of Fire Underwriters (currently American Insurance Association)
NFPA	National Fire Protection Association
OBC	Ontario Building Code
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
TEMA	Tubular Exchanger Manufacturers Association
ULC	Underwriters' Laboratories of Canada

1.6 Examine Site and Conditions

.1 Examine site and existing conditions. Examine carefully all Drawings and complete Specifications to ensure that work can be satisfactorily carried out as shown. Before commencing work, examine the work of other Sections and report at once any defect or interference affecting the work, its completion or warranty.

.2 No allowance will be made later for any expense incurred through failure to make these examinations or to report any such discrepancies in writing.

1.7 Contract Drawings

.1 Mechanical drawings do not show structural and related details. Take information involving accurate measurement of building from building drawings, or at building. Make, without additional charge, any necessary changes or additions to runs of piping, conduits and ducts to accommodate structural conditions. Location of pipes, ducts, conduits and equipment may be altered by the Consultant to suit site conditions. Consultant reserves the right to relocate services within 3m (10 ft.) in any direction from locations indicated on the drawings and Contractor shall carry out the change without any extra cost to the Owner.

.2 As work progresses and before installing mechanical equipment, registers, diffusers, fixtures and other fittings and equipment which may interfere with interior treatment and use of building, obtain detail drawings or directions for exact location of such equipment and fitments.

.3 Mechanical drawings indicate general location and route of pipes, ducts and conduits which are to be installed. Where required work is not shown or only shown diagrammatically, install same to conserve head room and interfere as little as possible with free use of space through which they pass. Conceal piping, conduits and ducts in furred spaces, ceilings and walls unless specifically shown otherwise. Install work close to structure so furring will be as small as practical.

.4 Prepare fully dimensioned interference drawings of products and services being installed indicating all interferences with other trades of work prior to installing the work. Any extra arising out of not preparing proper interference drawings

will not be paid by the Owner. Prepare layouts of Mechanical rooms, services, ceiling spaces and all other critical locations. Co-ordinate the work of all other Divisions. Interference drawings shall be based on shop drawings of equipment being installed. Indicate access, clearances, sleeves, electrical connections, drain locations, location of controller and elevations of pipes, ducts and conduits. Ensure that clearances required by jurisdictional authorities are indicated on the interference drawings.

.5 Install piping and ductwork to clear structural members and any fireproofing. Locate mechanical work to permit installation of specified installation. Do not remove or damage structural fireproofing. Leave space to permit fireproofing and insulation to be inspected and repaired.

.6 Before commencing work, check and verify all sizes, locations, grade and invert elevations, levels and dimensions to ensure proper and correct installation. Verify exterior services. Consult with Consultant to establish exact location. Any relocation caused by Contractor's failure to review with Consultant shall be done by Contractor at no extra cost to the Owner. Where job condition requires reasonable changes to indicated locations and arrangements, make changes to no extra cost to the Owner.

.7 Locate all mechanical and electrical equipment in such a manner as to facilitate easy and safe access to and maintenance and replacement of any part.

.8 In every place where there is indicated space reserved for future or other equipment, leave such space clear, and install piping and other work so that necessary installation and connections can be made for any such apparatus. Obtain instructions whenever necessary for this purpose.

.9 Relocate equipment and/or material installed but not coordinated with work of other Sections, without extra charge.

.10 The Specifications shall be considered as an integral part of the accompanying drawings. Any item or subject omitted from either the Specifications or the Drawings, but which is mentioned or reasonably implied in the other shall be considered as properly and sufficiently specified and must therefore be provided under this Division.

1.8 As-Built Drawings

.1 Conform to requirements of Section 01 78 39.

1.9 Cutting and Patching

.1 Lay out and install work in advance of other Sections. Bear all costs resulting from failing to comply with this requirement.

.2 Core drill holes in concrete walls and floors for piping where not previously sleeved. Coordinate all drill holes with Structural and Architectural. Do not use mechanical hammers or drills without prior approval in writing. Neatly patch holes to approval and where located in exterior walls above grade, make watertight. Make holes in walls below grade with due provision for pipe movement (min. 50mm clear all around), fill with 50mm thick fiberglass blanket insulation and seal watertight with mastic.

.3 See Sections relating to supports, hangers and sleeves and coordinate this work to other Sections to prevent unnecessary cutting and patching.

.4 This Contractor to cut and patch holes upto 200mm dia. (8”), where needed and patch neatly afterwards.

.5 Holes and openings larger than 200mm (8”) in diameter and the related patching is the responsibility of this Section and paid by the Mechanical Contractor requiring same.

1.10 Excavating and Backfilling

.1 Perform necessary excavating and backfilling for the work of this Division. Perform all work in accordance with the requirements of Section 31 00 00. 'Earthwork’. All pipes shall be kept on undisturbed natural ground.

1.11 Floor and Wall Plates

.1 Provide one piece nickel plated flanges of stamped brass in finished areas at points where exposed uncovered pipes pass through walls, floors or ceilings. Secure plates at ceiling with integral brass set screw.

.2 Split plates will not be accepted.

1.12 Valve Tags and Charts

.1 Tags shall be round brass plates with stamped numbers and/or letters as required. Tags shall be a minimum of 25mm (1") diameter and maximum to suit numbering system, numbered with nominal 13mm (1/2") high stamped letters and fastened securely with brass 'S' hooks or chains.

.2 Tags for sprinkler system supervisory and main operating valves shall be minimum 2mm (3/32") thick laminated phenolic plastic 125mm (5") long x 100mm (4") wide with red face and white center, 5mm (7/32") high letters shall be engraved through to the white lamination, with the following information:

- Valve number, System and Service;

- Fasten securely with brass chains.

.3 All valves shall be provided with tags. Provide charts indicating location, service and zone of each valve. Charts shall be set in finished wood or metal picture frames with lucite front and fastened securely where directed by the Consultant. This work shall be co-ordinated between the various mechanical sections to prevent overlapping of numbering systems.

.4 For all other valves on sprinkler systems not required to have laminated phenolic plastic tags, provide brass plates as specified above. Provide charts for all tags.

.5 Install one copy of each flow diagram and valve schedule mounted in frame with clear lexan where directed by Consultant. Provide one copy of all flow diagrams and valve schedules in each operating and maintenance instruction manual.

1.13 Cold Weather Work

.1 Wherever work is performed is surrounding air temperatures below 4^{o} C., special approved precautions shall be taken to prevent damage to materials and equipment.

1.14 Shop Drawings

.1 Refer to Section 01 33 00 regarding submission of shop drawings. Appropriately identify each shop drawing.

.2 Alternatively, submission of manufacturer's printed data sheets is acceptable providing all pertinent characteristics are identified and relate to specific items. Submit ten (10) copies of all data sheets.

.3 Submit shop drawings for, but not limited to, the following items:

.1 Plumbing fixtures and trim;
.2 Drainage specialties;
.3 Sprinkler layout drawings as approved by all authorities;
.4 Sprinkler system components;
.5 Thermometers and gauges;
.6 Fans;
.7 Heat Recovery Unit;
.8 Heat Pumps;
.9 Chemical Feed System;
.10 Diffusers, Registers and Grilles;
.11 Building Management System;
.12 Valves
.13 Fire Dampers
.14 Any other items of equipment as directed by the Consultant;

.4 Submit a schedule of shop drawings for approval no later than two (2) weeks after award of Contract, indicating the anticipated delivery dates.

Assume full responsibility for submission of shop drawings. Allow minimum five (5) days; maximum three (3) weeks for processing.

The Consultant will only review shop drawings after they have been corrected by the Contractor to conform to Contract Documents and have been dated and signed by him, and bear the Contractor's stamp of approval.

.5 Submit shop drawings, showing the following:

.1 Project name;
.2 Project tag number;
.3 Manufacturer's name and model number;
.4 Supplier's name;
.5 Approval agencies;
.6 Dimensions;
.7 Electrical characteristics;
.8 Materials used in manufacture and type of finish;
.9 Time required to fabricate and deliver;
.10 All variations from Tender documents.

The Consultant's review shall not relieve the Contractor from the responsibility of providing materials and equipment in accordance with the design intent and Contract Documents.

Circulate shop drawings to all Subcontractors for their review and comments prior to submission to the Consultant. Submit one (1) copy of shop drawing to Owner for review.

.6 Drawings will be marked and action taken as follows:

Consultant's Markings		Action by Contractor
.1	Reviewed	Proceed with work.
.2	Reviewed as modified	Proceed in accordance with markings. Resubmit revised drawings for record.
.3	Revise and Resubmit	Submit revised drawings for review before proceeding.

.7 Provide one (1) approved set of all shop drawings to the Subcontractor engaged to carry out the Testing, Adjusting and Balancing work.

1.15 Permits, Fees and Inspections

.1 Apply and pay for all permits, inspections, licences, fees and connection charges as required (Owner to pay for building permit). Comply with all applicable codes, regulations and authorities having jurisdiction.

.2 Comply with requirements of the latest edition of the applicable C.S.A. Standards, the requirements of the Authorities, Federal, Provincial and Municipal Codes, applicable Standards of the Underwriters' Association and all other authorities having jurisdiction. These codes and regulations constitute an integral part of these specifications. In case of conflict, the codes take precedence over the Contract Documents. In no instance reduce the standard established by the drawings and specifications by applying any of the codes referred to herein.

.3 Before starting any work, submit the required number of copies of drawings and specifications to the Authorities for their approval and comments. Comply with any changes requested as part of the Contract, but notify the Consultant immediately of such changes, for proper processing of these requirements. Prepare and furnish any additional drawings, details or information as may be required.

1.16 Project Documentation

.1 Provide a list of Subcontractors, equipment, suppliers and manufacturers of all equipment used in the installation indicating their full address, telephone number, fax number and name of person to be contacted for parts and service.

.2 Project documentation shall be in accordance with ASHRAE GPC-4, Preparation of Operating and Maintenance Documentation for Building Systems.

.3 The Contractor shall compile and deliver to the Consultant prior to applying for substantial performance and before the final inspection, three (3) complete Project Booklets. Each booklet shall consist of the following:

.1 Manufacturer's catalogue information on all major pieces of equipment.

.2 Manufacturer's maintenance instructions for same.

.3 One complete set of as-built drawings, as directed.

.4 Programming instructions for energy management and control systems.

.5 Copies of any certificates of approval issued by authorities having jurisdiction.

.6 Additional operational, maintenance and performance data as specified below.

.7 Documentation to confirm extended warranties on equipment.

.4 Operational data, including:

.1 Indicate safety features built-in for safe operation of the system and precautions to be taken while operating each equipment.

.2 Description of actions to be taken in event of equipment failure.

.3 Colour coding chart of piping and services as specified under 1.38 of this Section.

.5 Maintenance Data shall include:

.1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.

.6 Each book shall be bound in vinyl covered hard backed, 215mm x 279mm (8 1/2" x 11") size, three-ring covers at completion and before final acceptance of Work. Contents of books shall not include handwritten data.

.7 Review booklet with Owner's operating staff or representatives to ensure a thorough understanding of each item of equipment and its operation.

.8 Title sheet, in each book, shall be labelled "Project Data Book" and shall bear the following:

.1 Project Name
.2 Date
.3 List of Contents

.4 Refer to Specification Sections 01 70 00 and 01 78 23 for project close out submittals.

.5 Refer to Specification Section 01 29 00 for assigned costs valuation for project close out submittals.

1.17 Instructions to Owner

.1 Thoroughly instruct the Owner's representatives in all aspects of the operations of systems and equipment. This instruction shall be carried out only with express knowledge of and under the supervision of the Prime Subcontractor.

.2 Arrange and pay for services Engineers and other manufacturer's representatives required for instruction are specialized portions of the installation. Example: air conditioning, heat recovery unit, and other specialized mechanical systems.

.3 Allow for a minimum of eight (8) hours duration for each system/equipment.

.4 For training requirements of Building Automation Systems, see Section 23 09 23.

1.18 Vouchers

.1 When called upon to do so by the Consultant, produce vouchers to show that the work and materials are being paid for as the work progresses and to substantiate the value of the work completed to that date.

1.19 Valuation of Changes

.1 For each change submit a complete itemized breakdown of labour and material.

.2 Only the net difference between an extra and a credit will be subject to overhead and profit mark-up.

.3 Materials shall be valued at current trade prices incorporating all discounts and labour rates in accordance with union contracts at the time of issuing Notice of Change.

.4 Also see Section 1 – Tender Process Terms and Conditions

1.20 Temporary Use of Equipment

.1 The equipment and/or any part of the mechanical system shall NOT be used for temporary heating and/or cooling.

.2 Before any area of the building is turned over to the Owner for acceptance and for beginning of the guarantee/warranty period, the systems and equipment shall be returned to the initial new condition by replacing used air filters with new air filters, cleaning the air side of all coils in the air systems, bearings according to manufacturer's factory standards and adjusting the thermostatic control system according to specifications and to suit the Owner.

1.21 Phasing and Scheduling

.1 All trades shall co-ordinate their work so that delays, cutting and remedial work will be minimized. The trade(s) responsible for the ill-timed work shall be responsible for the remedial work.

1.22 Access Doors

.1 Supply access doors to all concealed mechanical equipment for operating, inspecting, adjusting and servicing.

.2 Flush mounted 600mm x 600mm (24" x 24") for body entry and 305mm x 305mm (12" x 12") for hand entry unless otherwise noted. Doors to open 180 degrees, have rounded safety corners, concealed hinges, screwdriver latches and anchor straps.

.3 Material:

.1 Special areas such as tiled or marble surfaces: use stainless steel with brushed satin or polished finish.

.2 Remaining areas: use prime coated steel.

.4 Installation:

.1 Locate so that concealed items are accessible.

.2 Locate so that hand or body entry (as applicable) is achieved.

.5 Supply 12 gauge hinged metal access doors with frames for installation by other Sections in walls or ceiling to permit access to built-in or unaccessible controls, dampers, valves, cleanouts and components. Where lift-out acoustic board ceilings are used, access doors are not required but boards shall be secured with accessible hold down clips and marked with Bildemup #6RH brass paper fasteners inserted through boards and bent over. Paint heads with red enamel before installation.

.6 Access doors shall be flush type of size to suit controls, valves, cleanouts, dampers or components serviced, minimum size 305mm x 305mm (12" x 12") "Reach-in", 305mm x 610mm (12" x 24") "Crawl in", with prime coat finish, concealed hinges, screwdriver lock and plaster key. Crawl in for ducts with dimensions larger than 600mm (24”).

.7 Access doors in roof overhangs, insulated ceilings and similar places shall have 38mm (1-1/2") rigid coated glass fibre insulation secured to back of gasketted screwdriver locked door, with frame to suit mounting surface.

.8 Access doors in fire rated ceiling assemblies, all fire rated walls, duct shafts or in corridor walls shall be UL, ULC, or WHI listed 1-1/2 hour fire rated temperature rise of maximum 120 deg. C. (250 deg. F.) in thirty (30) minutes. Access doors to be complete with screwdriver lock.

.9 This Contractor shall mark locations of all access doors, concealed valves, dampers and other concealed equipment. Method of marking shall be as directed by the Owner.

.10 Standard of Acceptance: 'Acudor'.

1.23 Lintels and Steel

.1 Lintels and steel required solely for the work of the mechanical equipment installation, and not shown on the architectural and structural drawings as being supplied and installed by a trade other than the mechanical, shall be supplied

and installed by the Mechanical Division and conform with requirements as indicated or called for on structural drawings.

1.24 Pipe and Equipment Supports

.1 General

.1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS-SP58.

.2 Support from structural members. Use suitable stainless steel lag bolts to secure to wood structure. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.

.3 Provide supports, hangers, etc. for the proper installation of the work.

.4 Construct all supports to safely carry the load under all operating conditions and testing.

.5 Provide all necessary inserts, hold down bolts, etc.

.6 Set all hanger rods vertical without bends or offsets. Connect hanger rods to the structure using approved inserts or beam clamps.

.7 *Provide oversize hangers for all sizes of pipes so that the insulation is continuous through the hangers.*

.2 Upper Attachments

.1 Concrete:

.1 Inserts for cast-in-place concrete: Galvanized steel wedge to MSS-SP58. Type 18. ULC listed for pipe NPS 3/4 through NPS 8.

.1 Standard of Acceptance: Grinnell fig. 281.

.2 Carbon Steel plate with clevis, for surface mount: Malleable iron socket and expansion case and bolt. Minimum two expansion cases and bolts for each hanger.

.1 Standard of Acceptance: Plate fig. 49; Socket Grinnell fig. 290; Expansion Case Grinnell fig. 117.

.3 Steel Beam (bottom flange):

.1 Cold piping NPS 2 and under: Malleable iron C clamp to MSS-SP58 Type 19, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 61.

.2 Cold piping NPS 2-1/2 and larger and all hot piping: Malleable iron beam clamp to MSS-SP58 Type 28 or 29, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 229.

.4 Steel Beam (top):

.1 Cold piping NPS 2 and under: Malleable iron "top of beam" C clamp to MSS-SP58 Type 19, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 61.

.2 Cold piping NPS 2-1/2 and larger and all hot piping: Steel jaw, hook rod with nut, spring washer and plain washer, to MSS-SP58 Type 25, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 227.

.5 Steel Joist:

.1 Cold piping NPS 2 and under: Steel washer plate with double locking nuts.

.1 Standard of Acceptance: Grinnell fig. 60.

.2 Cold piping NPS 2-1/2 and larger and all hot piping: Steel washer plates with double locking nut, carbon steel clevis and malleable iron socket.

.1 Standard of Acceptance: Grinnell: washer plate, fig. 60; clevis, fig. 66; socket, fig. 290.

.6 Steel channel or Angle (bottom):

.1 Cold piping NPS 2 and under: Malleable iron C clamp to MSS-SP58, Type 23, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 86.

.2 Cold piping NPS 2-1/2 and larger and all hot piping: Universal channel clamp, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 226.

.7 Steel Channel or Angle (top):

.1 Cold piping NPS 2 and under: Malleable iron "top of beam" C clamp to MSS-SP58 , Type 19, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 61.

.2 Cold piping NPS 2-1/2 and larger and all hot piping: Steel jaw, hook rod with nut, spring washer and plain washer, to MSS-SP58 , Type 25, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 227.

.3 Middle Attachment (rod):

.1 Carbon steel threaded rod electro-galvanized for mechanical rooms finish.

.1 Standard of Acceptance: Grinnell fig. 146.

.4 Pipe Attachment:

.1 Cold piping, steel or cast iron: hot piping steel, with less than 25mm (1") horizontal movement; hot piping, steel, with more than 300mm (12") middle attachment (rod) length: adjustable clevis to MSS-SP58 , Type 1, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 260.

.2 Cold copper piping; hot copper piping with less than 25mm (1") horizontal movement; hot copper piping with more than 300mm (12") middle attachment (rod) length: adjustable clevis to MSS-SP58 , Type 1, copper plated.

.1 Standard of Acceptance: Grinnell fig. CT-65.

.3 Suspended hot piping, steel and copper, with horizontal movement in excess of 25mm (1"); hot steel piping with middle attachment (rod) 300mm (12") or less; pipe roller to MSS-SP58 , Type 43.

.1 Standard of Acceptance: Grinnell fig. 181.

.4 Bottom supported hot piping, steel copper: pipe roller stand to MSS-SP58 , Type 45.

.1 Standard of Acceptance: Grinnell fig. 271.

.5 Riser Clamps:

.1 Steel or cast iron pipe: black carbon steel to MSS-SP58 , Type 42, ULC listed.

.1 Standard of Acceptance: Grinnell fig. 261.

.2 Copper pipe: carbon steel copper finished to MSS-SP58 , Type 42.

.1 Standard of Acceptance: Grinnell CT-121.

.6 Saddles and Shields:

.1 Cold piping NPS 1-1/4 and over: protection shield with high density insulation under shield with uninterrupted vapour barrier.

.1 Standard of Acceptance: Grinnell fig. 167.

.2 Hot piping NPS 1-1/4 and over: protective saddle with insulation under saddle.

.1 Standard of Acceptance: Grinnell fig. 160 to 166.

.7 Hanger Spacing:

.1 Spacing and middle attachment (rod) diameter as specified in paragraphs below or as in table below, whichever is more stringent.

.1 Plumbing piping: most stringent requirements of Ontario Plumbing Code, or authority having jurisdiction.

.2 Sprinkler Systems: to applicable fire code.

.3 Gas piping: up to NPS 1/2: every 1.8m.

.4 Copper piping: up to NPS 1/2: every 1.5m.

.5 Flexible joint roll groove pipe: in accordance with table below, but not less than one hanger at joints.

.6 Within 300mm (12") of each horizontal elbow.

.7 Hanger rod Diameter and spacing shall be as per following table:

Pipe Size: NPS	Rod Diameter	Max. Spacing Steel	Max. Spacing Copper
up to 1-1/4	10mm (3/8")	2.1m (7'-0")	1.8m (6'-0")
1-1/2	10mm (3/8")	2.7m (9'-0")	2.4m (8'-0")
2	10mm (3/8")	3.0m (10'-0")	2.7m (9'-0")
2-1/2	10mm (3/8")	3.6m (12'-0")	3.0m (10'-0")
3	10mm (3/8")	3.6m (12'-0")	3.0m (10'-0")
3-1/2	10mm (3/8")	3.9m (13'-0")	3.3m (11'-0")
4	16mm (5/8")	4.2m (14'-0")	3.6m (12'-0")
5	16mm (5/8")	4.8m (16'-0")	
6	22mm (7/8")	5.1m (17'-0")	
8	22mm (7/8")	5.7m (19'-0")	

.8 Hanger Installation:

.1 Offset hanger so that rod is vertical in operating position.

.2 Adjust hangers to equalize load.

.9 Wall Supports:

.1 Horizontal pipe adjacent to wall. Angle iron wall brackets with specified hangers.

.2 Vertical pipe adjacent to wall. Exposed pipe wall support for lateral movement restraint Grinnell Fig. 235 or 236.

.10 Floor Supports:

.1 Horizontal Pipe - Do not support horizontal pipes from the floor unless specifically indicated.

.2 Vertical Pipe - Risers passing through floor, riser clamps Grinnell Fig. 261.

.3 Base of risers adjacent to or above floor slabs - use adjustable fabricated steel floor supports.

.5 Concrete Work, Equipment Supports & Vibration Isolation

.1 Provide housekeeping pads under floor mounted equipment. Pads shall be 100mm (4") high concrete keyed to floor slab, extending 100mm (4") beyond equipment plan with 20mm (3/4") chamfered edges. Set all required anchor and hold down bolts.

.2 Provide supports for all equipment from the floor. Provide welded steel saddles for all tanks and equipment.

.3 For equipment suspended from the building structure, provide all structural members, platforms, brace and hanger rods as required. Method of attachment to be reviewed with the Structural Engineer before proceeding with the installation.

.4 Provide vibration isolation for all equipment and piping including hangers and neoprene pads under equipment.

.5 Vibration isolation shall be provided in accordance with the manufacturer's recommendations and the installation shall be certified by the supplier of the equipment.

1.25 Anchors and Guides

.1 Fabricate anchors and guides of structural steel channels, angles or plates secured to building structure. Size cylindrical type guides for full pipe insulation.

.2 Guides:

.1 Vertical Pipes

.1 Flexonics or equal alignment guides.

.2 Horizontal Pipes

.1 Grinnell Fig. 257 pipe slide assemblies or field fabricated guides using rolled T-sections welded to pipe.

.3 Install guides adjacent to expansion joints and loops. Consult expansion joint manufacturer's recommendations and follow his instructions for number and spacing of guides. Use a minimum of two guides on each side of expansion joint or loop.

.4 Guide Vertical Pipes

Up to 100mm (4")	- at every floor or 3m (10')
Larger than 100mm (4")	- at every second floor or 8m (25')

1.26 Pipe Sleeves

.1 Sleeves:

.1 Interior walls - Schedule 40 steel pipe.

.2 Exterior walls above grade - Schedule 40 steel pipe.

.3 Exterior walls below grade and waterproofed walls:

.1 extra heavy cast iron.

.4 Waterproof floors - (custodian rooms, mechanical rooms, kitchens, roofs) - extra heavy cast iron or DWV copper. Extend sleeves 100mm (4") above finished floor or slab.

.5 Interior floors - Schedule 40 steel pipe, 18 ga. galvanized steel.

.2 Installation:

.1 Sleeves shall be concentric with pipe.

.2 Size sleeves to permit continuity of insulation through sleeves.

.3 Install watertight concrete curb 100mm (4") high extending 100mm (4") beyond pipe at all sleeves passing through concrete floors except where furred in.

.4 Extend sleeves through outside wall 25mm (1") beyond exterior face of wall.

.5 Pack all sleeves between pipe or insulation and sleeve with loose fiberglass insulation and seal space both sides.

.3 Seal annular space as follows:

.1 Horizontal sleeves in exposed areas - use approved seal equal to fire rating of wall.

.2 Horizontal concealed sleeves through fire walls - seal with permanently resilient (silicone base or equal) sealing compound.

.3 Walls separating areas of different air pressure - seal with permanently resilient silicone base or equal) sealing compound.

.4 Vertical sleeves through roofs, janitors closets, equipment rooms and all floors - seal with permanently resilient waterproof (silicone base or equal) sealing compound.

1.27 Floor, Wall and Ceiling Plates

.1 Floors and Ceilings:

.1 Insulated and uninsulated pipe - use stamped steel, split type, chrome plated, concealed hinge, spring loaded with locking screws, suitable for external dimensions of piping or insulation.

.2 Wash Down Floors (equipment rooms, custodian rooms, utility rooms, washrooms):

.1 Insulated and uninsulated pipe - Grinnell Fig. 400.

.3 Walls

.1 Insulated pipe - flat seamed 65mm (2-1/2") wide x 1.2mm (18 ga.) thick galvanized steel band, snugly fitted over insulation and extending 50mm outside pipe sleeve.

.2 Uninsulated pipe - As for floors and ceilings.

.4 All exposed plates shall be chrome plated.

.5 Plates are not required in concealed locations.

1.28 Piping Expansion

.1 General: Install piping with all necessary changes of direction expansion loops, expansion offsets, expansion joints, anchors and guides so that expansion and contraction will not overstress the piping and equipment piping connections.

.2 Expansion Loops: Expansion loops and offsets shall be of all welded construction with long radius elbows cold spring 50% and located between anchors.

.3 Expansion Joints: Steel pipes 100mm (4") and smaller - Flexonics Type H-2 ply stainless steel bellows. Type, anti-torque devices, limit stops, internal guides with male ends.

Steel pipes 75mm (3") and larger. 304 stainless steel bellows, anchors, spacers, and shipping rods. Limit and guide rods, stainless steel liner and sheet metal shroud, flanged ends.

Alternate - Externally pressurized expansion joints.

Copper pipes - Flexonics type HB 2 ply bronze bellows.

Install spool pieces in place of expansion joints during pressure testing.

.4 Anchors: Anchors shall be fabricated from mild steel plate and structural steel angle and channel sections in accordance with ANSI B.31.

.5 Guides: Install guides as specified in article 1.26 'Anchors & Guides'.

1.28 Piping Expansion(cont.)

.6 Braided Flexible Hoses: Braided flexible hoses shall be monel or stainless steel convoluted bellows type with braided stainless steel sleeves.

Use screwed connections up to 50mm (2") diameter and flanged 65mm (2-1/2") and larger.

Select braided hoses for the required operating pressure.

Install a union at one end on hoses up to 50mm (2") diameter.

Ensure that hoses are not damaged during hydrostatic testing.

1.29 Flashing

.1 Flash all mechanical parts passing through, or built into an outside wall or a waterproof floor.

.2 Provide sleeves for pipes passing through roof, floor and outside walls.

.3 Install stacks and ducts passing through the roof, counterflashing to fit over the curb.

.4 Plumbing vents through roof shall be ‘Thaler’, Stack Jack model SJ-100 or approved equal.

.5 For ducts passing through roof, counterflashing will be provided by Section 07510.

1.30 Unions and Flanges

.1 Unions in copper pipes shall be wrought copper and soldered joints for pipes 51mm (2") diameter and smaller, brass ground joints for 63mm (2-1/2") and 76mm (3") pipes. For copper pipes larger than 76mm (3") flanges shall be 68 kg (150 lbs.) cast brass. Unions in steel pipes shall be Dart for pipes 51mm (2") diameter and smaller, and flanged fittings for 63mm (2-1/2") and larger pipes. Provide unions or flanges at all connections to equipment requiring servicing or replacing. Connections between steel and copper pipe shall be through dielectric unions to prevent electrolytic action.

1.31 Pipe Anchors

.1 Obtain Consultant's approval on method of anchoring prior to roughing-in.

.2 Take special care, when selecting location of pipe anchors, to avoid the introduction of undue reaction forces and operation weights in the structure of

the building, into flanges of pumps and other equipment and to avoid excessive pipe stresses.

.3 Anchors shall be suitable design to restrain movement of pipe in all directions due to the reaction forces. Do not use anchors which are designed to resist pipe-axial forces only.

1.32 Dissimilar Metals

.1 Where dissimilar metals are in close proximity to each other, they shall be separated by means of waterproof gaskets or shims of approved materials. Screws, bolts, rivets and other fastening devices shall be made of the same materials or of metals which they fasten, in order to prevent electrolytic action. Provide dielectric unions between steel and copper pipes.

1.33 Thermometers

.1 Provide thermometers at locations indicated on drawings.

.2 Thermometer shall be Bi-metal type 125mm (5") dial adjustable angle type stainless case and stem complete with re-calibrator screw, 100mm (4") stem complete with 20mm (3/4") brass thermowall (C.R.N. registered in Ontario). Range to suit equipment service. Review with Consultant prior to ordering.

.3 Standard of Acceptance: Trerice B85604.

1.34 Pressure Gauges

.1 Provide pressure gauges at locations indicated on piping schematic drawing.

.2 Pressure Gauge shall be ANSI B40.1 Grade 'A' accuracy, phosphor bronze tube, forged brass socket, cast aluminum case, bottom outlet, movement to be bronze brushed rotary type, pointer to have adjustable hub, dial 115mm (4-1/2") white scale black figures. Dual PSI/KPa markings; Range to suit service; maximum 1-1/2 times service pressure.

.3 Accessories

.1 Pressure snubber bar stock to be with cintred bronze insert 1/4" NPT 1000 PSI rated, Trerice 872-2.

.2 Pressure shut off valve to be bar stock brass 1/4" needle valve 1000 PSI rated, Trerice 735-2.

.4 Standard of Acceptance: Trerice 600 Series quality level (C.R.N. registered in Ontario). Gauges to be silicone dampened.

1.35 Drains and Vents

.1 At the low points of all systems (except drains), carrying fluids provide 19mm (3/4") threaded hose end drain cocks located to allow easy connection of hose to drain.

.2 Provide manual air vents with isolating cock at all high points, minimum size 19mm (3/4”). Run 6mm (1/4") copper tube overflow to terminate over nearest hub drain or service sink.

1.36 Electric Motors and Wiring

.1 Electric connections and power wiring for equipment supplied under this Division will be by the Electrical Division. This Division shall provide all control wiring to complete the systems. All electrical work must conform to conditions noted in Electrical Division and be concealed except in service areas.

.2 Electronically operated equipment shall be C.S.A. approved and bear approval label. Special Inspection Label of Provincial Authority having jurisdiction will be accepted in lieu of C.S.A. approval for each motor. Provide an approved starter.

.3 Supply motor starters, controls and accessories required to operate equipment installed. Supply necessary wiring diagrams and instructions to Electrical Division. Starters and controls shall be for surface or flush mounting as required. Arrange equipment, piping and ductwork to permit access to and mounting of starters and controls. Co-operate with Electrical Division to ensure electrical equipment can be installed and serviced. See Electrical Drawings.

.4 Electrically operated equipment, starters and controls shall be rated for satisfactory operation on following nominal system voltages unless otherwise noted:

up to and including 0.25 kW - 60/1/120V
0.37 kW and larger - 60/3/208V or 60/3/575 as noted.

.5 Magnetic starters shall be combination type complete with disconnect feature (breaker) unless starter is built into unit control panel.

.6 Provide starting apparatus for prime plumbing, heating and ventilating equipment so that these units will automatically restart on resumption of power outage. Starters for these units shall have 'ON/OFF' selector switch in cover if not fitted with H.O.A. selector feature. For heat pump units over 17.5 kW (5.0 Tons) cooling capacity provide remote wall mounted starters. Locate as indicated on drawings or as directed at site.

.7 Where control panels are supplied as loose item by equipment manufacturers, mount the panels as directed at site and provide control wiring between the control panels and the controlled equipment.

.8 Each three phase starter shall be complete with pilot light, overload heaters and 120V control coils. Fit each single phase starter with neon lamp pilot light and three phase starters with transformer type incandescent with amber lens cap. Fit each three phase starter with at least two auxiliary contacts. Fit each three phase starter with three overload heaters. Size overload heaters at maximum 115% of actual unit motor name plate rating.

.9 Where equipment is noted to be electrically interlocked, supply necessary interlocks via double voltage relays (mylar shroud accepted) to ensure specified operation. Magnetic starters shall be breaker type except where power is taken from separate protected circuit or is otherwise protected. Electrical interlocks

and control devices shall operate on 120 volts A.C. maximum. Provide necessary fused and grounded control transformers to suit.

.10 All motors supplied as a part of Mechanical equipment or otherwise shall be of the high efficiency 'type' and shall meet or exceed Ener-Mark Efficiency Level for their particular class of speed and horsepower. Motors shall be TEFC or OFP type and shall run at 1800 rpm unless noted otherwise. All motors supplied shall have a minimum Efficiency Level as listed below:

Motor Size (HP)	Efficiency @ 1800 RPM (%)
1.0	86.5
1.5	87.5
2.0	87.5
3.0	90.2
5.0	90.2
7.5	92.4
10.0	92.4
15.0	93.0
20.0	93.6
25.0	93.6
30.0	94.1
40.0	94.5
50.0	95.0
60.0	95.0
75.0	95.4
100.0	95.8
125.0	95.8
150.0	96.2
200.0	96.5

.11 All exposed mounted starters shall be of ONE manufacturer. Fit fuse gaps in fusible equipment for motors with complete set of proper size Form 2, Class C HRC English Electric current limiting fuses (Form 1 NEMA 'J' for contactors and non-motor uses). Ensure fusible equipment supplied will reject standard NEC fuses. Co-ordinate fuses for motors to give maximum protection, and of one manufacturer throughout. Supply to Owner three fuses of each size suitably labelled. Obtain duplicate receipt for same. Submit for review complete list of all starters showing make, size, accessories, labels and fusing.

.12 Starters shall be built and tested to NEMA Standards only. IEC designs will not be acceptable. Starters that are interlocked with other equipment shall be combination breaker type complete with magnetic starter, 3 overloads, HOA switch, green running pilot lights and with ON-BOARD communication capability in order to communicate with Building Management System (BMS).

.13 Unless otherwise stated, the following work shall be handled by the Divisions as mentioned. Mechanical means either Plumbing and Drainage Section or Heating, Ventilation and Air Conditioning Section. All power wiring above 100 volts except as noted in Section 23 09 23 shall be carried out by Electrical Division, and all low voltage, below 100 volts, components shall be supplied, installed and wired by the Mechanical Section involved. All control wiring including interlocking wiring regardless of voltage shall be done by this division.

.14 Electrical items supply and installation shall be according to the following chart:

ITEM	SUPPLIED BY	INSTALLED BY	CONNECTED BY
Starters, including those Supplied loose as a part of Packaged equipement	Mechanical	Electrical	Electrical
Disconnects (for mechanical equipment)	Mechanical	Electrical	Electrical
Electrical Unit Heaters	Electrical	Electrical	Electrical
Electric Force Flow Heaters	Electrical	Electrical	Electrical
Exhaust Fan Interlock	Mechanical	Mechanical	Mechanical
Motorized Dampers	Mechanical	Mechanical	Mechanical
Low Voltage Control Wiring	Mechanical	Mechanical	Mechanical
Control Wiring (any voltage)	Mechanical	Mechanical	Mechanical

.15 Standard of Acceptance: Westinghouse Canada Limited

1.37 Noise and Vibration

.1 Mechanical equipment shall operate without objectionable noise or vibration.

.2 However if such objectionable noise or vibration should be produced and transmitted to an occupied portion of the building, make necessary changes and/or additions as approved, without extra cost to the Owner.

1.38 Identification of Piping and Equipment

.1 Manufacturers Nameplates:

.1 Provide metal nameplate on each piece of new equipment, mechanically fastened complete with raised or recessed letters.

.2 Indicate size, equipment model, manufacturer's name, serial number, voltage, cycle, phase and power of motors.

.3 Locate nameplates so that they are easily read. Do not insulate or paint over plates.

.4 All identification shall be provided as per City of Toronto Standards.

.2 System Nameplates:

.1 Colour:

.1 Hazardous: red letters, white background.

.2 Elsewhere: black letters, white background (except where required otherwise by applicable codes or City of Toronto Standards).

.2 Construction:

.1 3mm (1/8") thick, laminated plastic or white anodized aluminum, matte finish, square corners, letters accurately aligned and machine engraved into core.

.3 Locations:

.1 In conspicuous location to facilitate easy reading from operating floor and to properly identify equipment and/or system.

.2 Provide stand-offs for nameplates on hot surfaces and insulated surfaces.

.4 Sizes:

.1 Conform to following table:

Size #	Dimensions (mm x mm) (in x in)	No. of Lines	Letter Height (mm) (in)
1	10mm x 50mm (3/8" x 2")	1	3mm (1/8")
2	13mm x 75mm (1/2" x 3")	1	5mm (3/16")
3	13mm x 75mm (1/2" x 3")	2	3mm (1/8")
4	20mm x 100mm (3/4" x 4")	1	8mm (5/8")
5	20mm x 200mm (3/4" x 8")	1	8mm (5/8")
6	20mm x 100mm (3/4" x 4")	2	5mm (3/16")
7	25mm x 125mm (1" x 5")	1	12mm (1/2")
8	25mm x 125mm (1" x 5")	2	8mm (5/8")
9	35mm x 200mm (1 3/8" x 8")	1	20mm (3/4")

.2 Use average of 25 letters/numbers (maximum) per nameplate.

.3 Use size #6 for terminal cabinets and control panels.

.4 Use size #9 for equipment in mechanical rooms.

.5 Piping:

.1 Identification:

.1 To CGSB 24-GP-3a.

.2 Identify medium by lettered legend, classification by primary and secondary colours, direction of flow by arrows.

.2 Sizes:

.1 Legend: block capitals to following table:

Outside Dia. of Pipe or Insulation	Size of Letters
30mm (1/4")	13mm (1/2")
50mm (2")	19mm (3/4")
150mm (6")	32mm (1 1/4")
250mm (10")	63mm (2 1/2")
Over 250mm (10")	88mm (3 1/2")

.3 Primary colour bands:

.1 At valves and fittings: 500mm (20") long.

.2 Elsewhere: 1000mm (3'-4") long.

.3 Secondary colour bands: 50mm (2") wide, 75mm (3") in from one end of primary colour band.

.4 Arrows:

.1 Outside diameter of pipe/insulation 75mm (3") and greater: 150mm long x 50mm (6" x 2") high.

.2 Outside diameter of pipe/insulation less than 75mm (3"): 100mm long x 50mm high (4" x 2").

.3 Use double headed arrows where flow is reversible.

.3 Material:

.1 Paint: to CGSB 1-GP-60M.
.2 Legend markers, arrow colour bands: plastic coated cloth material with protective overcoating and waterproof contact adhesive undercoating, suitable for 100% RH and continuous operating temperature of 150C (300F) and intermittent temperature of 200C (400F). Apply to prepared surfaces. Use stencilling for identification.
.3 Waterproof and heat resistant plastic marker tags: for pipes and tubing 20mm (3/4") nominal and smaller.

.4 Colours:

.1 Where not covered by table below, submit legend, primary and secondary classification colours to Consultant for approval.

.5 Table:

.1 Pipe and valve identification.

Pipe Marker Legend	Valve Tag Legend	Primary Colour	Secondary Colour

City Water	CI.W	Green	None
Dom hot water supply	D.H.W.S.	Pink	None
Dom tempered water supply	D.T.W.S.	Pink	None
Dom hot water recirc	D.H.W.R.	Pink	None
Heating supply, high temp	H.S.H.T.	Medium Orange	Black
Heating return, high temp	H.R.H.T.	Pale Orange	Black
Heating supply, low temp	H.S.L.T.		
Heating return, low temp	H.R.L.T.		
Make-up water	M.U.W.	Yellow	Black
Storm sewer	S.S	Green	None
Sanitary sewer	SAN.S	Green	None
Refrigerant suction (include refrig no.)	REF.S	Yellow	Black
Fire protection water	F.P.W.	Red	White
Vent (plumbing)	V.P	Green	None
Natural Gas	G	Yellow	Orange

Note: Additional identification of services as required and as instructed.

.2 Legend and Arrows:

.1 Black or white to contrast with primary colour.

.2 Fire protection: white on red background.

.3 Also refer to Section 09900, 'Painting'.

.6 Fire Protection System:

.1 Exposed piping (except sprinkler branches): paint complete system and identify.

.7 Locations of Piping Identification:

.1 On long straight runs in open areas at not more than 17m (51') intervals.

.2 Adjacent to all changes in direction.

.3 On both sides of visual obstruction or where run is difficult to follow.

.4 On both sides of any separation such as walls, floors and partitions.

.5 Where piping is concealed in pipe chase, gallery or other confined space, at entry and leaving points and adjacent to each access opening.

.6 At beginning and end points of each run and at each piece of equipment in run.

.7 Legend to be easily and accurately readable from usual operating areas and all readily accessible points.

.8 Plane of legend to be approximately at right angles to most convenient line of sight with consideration of operating positions, lighting conditions,

reduced visibility of colour or legends caused by dust and dirt and risk of physical damage.

.8 Ductwork:

.1 50mm (2") high black stencilled letters and directional flow arrows 150mm long x 50mm (6" x 2") high.

.2 Locations of ductwork identification:

.1 Follow all rules cited for piping.
.2 Beside each access door.
.3 Stencil over final finish only.

.9 Valves:

.1 Brass tags with 12mm (1/2") stamped code lettering and numbers.

.2 Furnish Consultant with 6 identification flow diagrams for each system. Include valve tag schedule, designating number, service, function and location of each tagged item and normal operating position of valves.

1.39 Superintendence

.1 Maintain at the job site at all times qualified personnel and supervisory staff with proven experience in construction, managing, testing and commissioning projects at comparable size, nature and complexity. Any individual deemed to be unsatisfactory by the Consultant shall be replaced.

1.40 Workmanship

.1 All work shall conform to standards of excellence and good practice of the respective trades. Governing Codes and regulations represent the minimum acceptable standards.

1.41 Starting Up

.1 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.

.2 Arrange for the manufacturers to provide demonstrations and instructions.

.3 Use operation and maintenance manuals, and as-built drawings.

1.42 Field Review

.1 The Owner and Consultant shall have access to the site at all times for review of the work during construction.

.2 Arrange for review of Products during manufacture.

.3 Provide all gauges, instruments and other necessary measuring equipment required for review of the Work.

.4 Maintain a complete set of Contract Documents at all times for field reference by the Consultant.

.5 Correct any deficiencies as they are reported during the performance of the Work.

1.43 Services to Equipment

.1 Provide all necessary connections required for equipment supplied by the Owner and other Divisions. Examine all Drawings and Specifications and identify all requirements.

.2 Provide valves, unions, caps and vibration isolation for all services.

1.44 Final Inspection

.1 Request in writing for a final inspection of mechanical and electrical systems.

.2 Do not submit this written request until:

.1 Deficiencies noted during job inspections have been completed.

.2 Systems have been balanced and tested and are ready for operation.

.3 Balancing reports have been submitted and approved.

.4 Completed data books have been submitted and approved by Consultant and Owner.

.5 Tags are in place, valve charts and line diagrams have been submitted and approved, and equipment identification is completed.

.6 The cleaning up is finished in every respect.

.7 Certificates are hung.

.8 Spare parts and replacement parts specified have been provided and receipt of same acknowledged.

.9 Record Drawings are completed and approved.

.10 Owner's operating personnel have been instructed in operation of systems.

.11 Commissioning reports from all suppliers/manufacturers confirming that the equipment and/or systems have been installed as per their recommendations.

1.45 Spare Parts

.1 Furnish spare parts as follows:

.1 One set of V-belts for each piece of machinery, including heat recovery unit, fluid cooler and heat pumps (where applicable).

.2 One set of spare filters for heat recovery unit and each air moving equipment. Tag each filter unit with the respective unit number. Provide a list of filters.

1.46 Testing, Adjusting and Balancing

.1 General:

.1 Testing, Adjusting and Balancing will be carried out by an independent company specialized in this type of work and the cost of this work will be paid out of Cash Allowances, see Section 01 21 00.

.2 Co-operate with the balancing firm to:

.1 provide sufficient time for testing and balancing prior to substantial completion;

.2 adjust systems and components (drives, sheaves, belts, etc.) as required;

.3 maintain systems in full operation during testing and balancing;

.4 check and correct alignment of V-belts, drive shaft coupling drives, etc.;

.5 be liable to co-operate with the balancing company to carry on their job, make available all equipment data (shop drawings, performance data and operating instructions) at the request of the Balancing company;

.6 assist the balancing company by providing their mechanics with ladders, tools, test holes and coverplates, etc., as directed by balancing company, consult balancing company for the location and type of dampers, valves, test holes, access doors, etc., and the position of the dampers and valves they have to set when installing them;

.7 after testing and balancing is complete, cover all testing holes, fix guards, etc., and replace whatever was removed.

PART 2 - PRODUCTS - NOT APPLICABLE

PART 3 - EXECUTION

3.1 Equipment Installation

.1 Unions or flanges: provide for ease of maintenance and disassembly.

.2 Space for servicing, disassembly and removal of equipment and components: provide as recommended by manufacturer or as indicated.

.3 Equipment drains: pipe to floor drains.

.4 Install equipment, rectangular cleanouts and similar items parallel to or perpendicular to building lines.

3.2 Anchor Bolts and Templates

.1 Supply anchor bolts and templates for installation by other divisions.

3.3 Trial Usage

.1 Consultant and Owner may use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.

.2 Trial usage to apply to the following equipment and systems:

.1 heating and air conditioning systems
.2 ventilation and exhaust systems
.3 domestic hot water system

3.4 Protection of Openings

.1 Protect equipment and openings from dirt, dust, and other foreign materials.

3.5 Electrical

.1 Electrical work to conform to, and to be coordinated with, Division 16.

3.6 Motors

.1 Provide motors for packaged mechanical equipment as specified on the drawings.

.2 If delivery of specified motor will delay delivery or installation of any equipment, install motor approved by Consultant for temporary use. Final acceptance of equipment will not occur until specified motor is installed.

.3 Motors under 373W (0.5 HP): speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120 V, unless otherwise specified or indicated.

.4 Motors 373W (0.5 HP) and larger: EEMAC Class B, squirrel cage induction, speed as indicated, continuous duty, drip proof, ball bearing, maximum temperature rise 41C, 3 phase, 208 V or 600 V, unless otherwise specified or indicated.

.5 Motors 0.75KW (1.0 HP) and above shall be of high efficiency type as listed herein.

3.7 Belt Drives

.1 Fit reinforced belts in sheave matched to drive. Multiple belts to be matched sets.

.2 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise specified.

.3 For motors under 7.5kW (10.0 HP): standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.

.4 For motors 7.5 kW (10.0 HP) and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.

.5 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.

.6 Motor slide rail adjustment plates to allow for center line adjustment.

3.8 Guards

.1 Provide guards for unprotected drives.

.2 Guards for belt drives:

.1 Expanded metal screen welded to steel frame.

.2 Minimum 1.2mm thick sheet metal tops and bottoms.

.3 Removable for servicing.

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

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

.5 Guard for flexible coupling:

.1 "U" shaped, minimum 1.6mm thick galvanized mild steel.

.2 Securely fasten in place.

.3 Removable for servicing.

.6 Unprotected fan inlets, outlets, open ended return air ducts and transfer air ducts (both ends):

.1 Wire or expanded metal screen, galvanized, 19mm mesh.

.2 Net free area of guard: not less than 80% of fan openings.

.3 Securely fasten in place.

.4 Removable for servicing.

.7 Any rotating device must be guarded to comply with Ministry of Labour “Finger Test”. Standard manufacturer’s guards do not normally meet this requirement and additional guards are usually necessary.

Shaft Ends: All shaft ends must be guarded.

Any equipment which uses the casing as a guard shall have a notice of warning affixed to the access panel to this effect. Minimum letter size for warning to be 25mm (1”).

3.9 Equipment Supports

.1 Equipment supports supplied by equipment manufacturer: specified elsewhere in this Mechanical Specification.

.2 Equipment supports not supplied by equipment manufacturer: fabricate from structural grade steel.

3.10 Sleeves

.1 Pipe sleeves: at points where pipes pass through masonry, concrete or fire rated assemblies and as indicated.

.2 Schedule 40 steel pipe.

.3 Sleeves with annular fin continuously welded at midpoint:

.1 Through foundation walls.

.2 Where sleeve extends above finished floor.

.4 Sizes: minimum 6mm clearance all around, between sleeve and uninsulated pipe or between sleeve and insulation.

.5 Terminate sleeves flush with surface of concrete and masonry walls, concrete floors on grade and 25mm (1") above other floors.

.6 Fill voids around pipes:

.1 Caulk between sleeve and pipe in foundation walls and below grade floors with waterproof fire retardant non-hardening mastic.

.2 Where sleeves pass through walls or floors, provide space for firestopping. Where pipes/ducts pass through fire rated walls, floors and partitions, maintain fire rating integrity.

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

.4 Fill future-use sleeves with lime plaster or other easily removable filler.

.5 Coat exposed exterior surfaces of ferrous sleeves with heavy application of zinc rich paint to CGSB 1-GP-181M + Amdt-Mar-78.

3.11 Preparation for Firestopping

.1 Firestopping material and installation within annular space between pipes, ducts, insulation and adjacent fire separation.

.2 Uninsulated unheated pipes not subject to movement: no special preparation.

.3 Uninsulated heated pipes subject to movement: wrap with non-combustible smooth material to permit pipe to move without damaging firestopping material.

.4 Insulated pipes and ducts: ensure integrity of insulation and vapour barrier at fire separation.

3.12 Escutcheons

.1 On pipes passing through walls, partitions, floors and ceilings in finished areas.

.2 Chrome or nickel plated brass or Type 302 stainless steel, one piece type with set screws.

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

3.13 Tests

.1 Give 48 hours written notice of date for tests.

.2 Insulate or conceal work only after testing and approval by Consultant.

.3 Conduct tests in presence of Consultant.

.4 Bear costs including retesting and making good.

.5 Piping:

.1 General: maintain test pressure without loss for 4 hours unless otherwise specified.

.2 Fill with solution of water and non-foaming, phosphate-free detergent 3% solution by weight. Circulate for a minimum of 8 hours.

.3 Drain and flush out for 4 hours. Remove and clean strainers.

.4 Refill system with clean water and circulate minimum 2 hours.

.5 Drain and flush out for 2 hours. Remove and clean strainers.
.6 Refill the system after obtaining Consultant's approval.

.7 Hydraulically test heating piping systems at 1-1/2 times system operating pressure or minimum 860 kPa (125 psi), whichever is greater.

.8 Test drainage, waste and vent piping to National Building Code and authorities having jurisdiction.

.9 Test domestic hot, cold and recirculation water piping at 1-1/2 times system operating pressure or minimum 860 kPa (125 psi), whichever is greater.

.10 Test fire systems in accordance with authorities having jurisdiction and as specified elsewhere.

.11 Test gas piping in accordance with Gas Utilization Code.

.6 Equipment: test as specified in relevant sections.

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

3.14 Painting

.1 Apply at least one coat of corrosion resistant primer paint to ferrous supports and site fabricated work.

.2 Prime and touch up marred finished paintwork to match original.

.3 Restore to new condition, finishes which have been damaged too extensively to be merely primed and touched up.

.1 To be compatible with and to suit pressure rating of piping system.

.2 Where pipes of dissimilar metals are joined.

.3 Pipes NPS 50mm (2") and under: isolating unions.

.4 Pipes NPS 65mm (2-1/2") and over: isolating flanges.

3.15 Drain Valves

.1 Locate at low points and at section isolating valves unless otherwise specified.

.2 Minimum NPS 3/4 unless otherwise specified: bronze, with hose end male thread and complete with cap and chain.

3.16 Cleaning

.1 Clean mechanical systems in accordance with manufacturer's recommendations prior to start up.

.2 Clean interior and exterior of all systems including strainers. Vacuum interior of all ductwork and air moving units.

.3 In preparation for final acceptance, clean and refurbish all equipment and leave in operating condition including replacement of all filters in all air and piping systems.

3.17 Deficiencies

.1 Any deficiencies not removed prior to the occupancy of the building shall be corrected during building unoccupied hours.

3.18 Hazardous Materials

.1 Submit data sheets for all proposed caulking, solvents, materials containing solvents or volatile chemicals. These data sheets are required immediately following award of the contract.

.2 Do not specify and use materials recognized by the Government of Ontario or other authorities having jurisdiction as being hazardous to health and safety.

3.19 General Installation Requirements

.1 The Consultant's Drawings and instructions govern the location of all items of work.

.2 Install equipment neatly to the satisfaction of the Consultant. Unless noted otherwise, install all products and services to follow building plans. Installations shall permit free use of space and maximum headroom.

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

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

.5 Provide suitable shielding and physical protection for all devices.

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

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

.8 Do not use explosive activated tools.

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

.10 Cap off and seal all open ends of installed ductwork, piping and conduits to prevent entrance of foreign matter.

.11 Do not install piping in a location or manner which might result in freezing.

.12 Install all services capped for future to allow easy access for future tie-in.

.13 Test all plumbing fixtures for soundness, stability of support and correct operation.

.14 Flush all completed fluid-carrying systems with clear water at the highest obtainable pressure and velocity. Clean all strainers and repeat flushing operation to the approval of the Consultant until no foreign material collects in the strainers. Drain and clean all apparatus remove and clean strainer filters, replace if necessary. Provide new seals in the circulating pumps after flushing and cleaning is carried out. Use Drew Chemicals solution CSW600 or Dearborn FQ7103 for flushing the system to remove mill scale, dirt and oil deposits.

.15 Sterilize domestic hot and cold water piping. Fill all recirculating water systems with an approved detergent type cleaner upon completion of flushing. Establish flow in the systems in accordance with the instructions of the cleaning compound manufacturer and maintain circulation for at least 72 hours. Upon completion of the above, flush the system clean of all traces of the cleaning compound and clean all strainers. Refill the systems immediately and add the necessary water treatment chemicals to obtain the specified water quality.

.16 The supplier of the chemical treatment system shall supervise and certify flushing and cleaning of all systems.

.17 During flushing and cleaning maintain all isolating and control valves in the open position.

.18 Clean all completed ductwork and apparatus internally and cap cleaned sections.

.19 Inspect and clean the inside and outside of all air handling systems (fans, ducts, coils, and heat pumps) before starting up any fans. Ensure that they are free from dust and debris.

.20 Prior to requesting for substantial completion, replace all air filters in all units with a new set of filters. These shall be in addition to those specified herein under 1.45.

.21 Provide a test report verifying that antifreeze levels indicated in the contract documents are met.

3.20 Completion

.1 Nothing contained herein, or on the Drawings shall be construed to relieve the Contractor from making good and perfect, in all the usual details of construction, the work involved in the completion of this Contract.

.2 On completion of the work of this Division, all protection erected under this Division shall be removed, all damage to this work and adjoining surfaces made good, all surplus materials and debris, tools, plant and equipment provided under this Division removed from the premises and the site left clean and tidy to the Consultant's satisfaction.

3.21 Warranty and Maintenance

.1 All labour, equipment and materials provided by this contractor shall be warranteed for a period of 2 year from the date of substantial performance. Replace any faulty equipment and materials at no cost to the owner during this period. Extended warrantees shall be maintained as further specified.

.2 The maintenance of the mechanical systems during the warranty period shall be by the installing contractor. This shall include all lubrication, belts and water treatments. Three (3) maintenance inspections shall be provided in the presence of the Owner's representative.

.3 Refer to Specification Sections 01 70 00 and 01 78 23.

END OF SECTION

1 Part 1 - General

1.1. Application

This Section specifies commissioning requirements that are common to Mechanical Divisions Work Sections and it is a supplement to each Section and is to be read accordingly. When requirements of this Section contradict requirements of Divisions 21 through 24, conditions of Divisions 21 through 24 to take precedence. All commissioning and testing shall be fully documented and all documentation shall be submitted to the Owner's designate Commissioning Agent prior to Demonstration and acceptance testing. Commissioning shall include a point-to point check-out (functional test) of the following at the minimum:

.1 Verify that all Temperature Control Panels, BAS equipment, controllers, devices and sensors are installed and operational according to the specifications, submittals and manufacturer's installation and application instructions.

.2 Verify that all wires have been properly labelled (at both ends of termination, control devices/sensors labelled, controllers labelled and wiring diagrams of controller termination installed within the panel.

.3 Test, calibrate and bring on-line every control device. Calibrate all inputs by comparing the actual site condition with the point display at the Operator's graphical user interface (GUI).

.4 Verify all outputs from GUI command to observed response of controlled device.

.5 Verify failure response and fail-safe conditions of all devices and safeties.

.6 Each control program shall be fully commissioned and tested for complete design intent compliance and functionality.

.7 Verify overall network performance of BAS for complete design intent compliance and functionality with all devices on-line, communicating and fully-operational.

.8 Subsystems not directly controlled by the BAS but associated with the main system shall also be fully tested and commissioned as to design intent compliance and functionality.

.9 Provide completed Pre-commissioning (Pre-Functional Test) Check List to Owner's designate Commissioning Agent.

1.2. Vendor Assistance

Vendor shall provide assistance, staff and materials to support the Owner's designate Commissioning Agent activities. This includes:

.1 Provision of all testing apparatus in use by the vendor to test and calibrate or verify calibration of control system and all other apparatus for which the vendor has control or calibration responsibility.

.2 Assistance includes but is not limited to reviewing test procedures and providing software enhancements to accommodate testing methods.

.3 On-site programmer/control technician to carry out the operator commands and adjustments to software parameters as directed by the Owners designated Commissioning Agent.

.4 Vendor shall provide staff and materials to support the point-to point function testing, also referred to as Owner-Witnessed Testing as well as the Performance Verification Testing.

1.3. Commissioning Agent Involvement Versus Warranty Obligations

.1 Involvement of Commissioning Agent performing duties as described in this Section is not in any way to void or alter any Contractual warranty obligations.

1.4. Commissioning Agent

.1 Commissioning Agent will be retained and paid by Owner to perform mechanical work commissioning specified in this Section. Cooperate in all respects with Owner's Commissioning Agent.

1.5. Quality Assurance

.1 Commissioning work is to be in accordance with requirements of following:

.1 CSA Z320, Building Commissioning Standard and Check Sheets;

.2 ASHRAE Guideline 0, The Commissioning Process;

.3 ASHRAE Guideline 1.1, The HVAC Commissioning Process;

.4 Owner designated Commissioning Agent.

1.6. Description

.1 Commissioning is a systematic process of ensuring that all building systems installed in accordance with the drawings and specifications, manufacturer's requirements and good industry practice. Commissioning also ensures that equipment operates and performs, in and of itself as well as in the system, as was intended by the designers in response to the owner's requirements. The commissioning activities should ensure that it will comply with TGS Version 3.0 Standards. Finally commissioning ensures the owner has the documentation and training required to operate the equipment and systems in a safe, efficient and long-lasting manner.

.2 During the construction phase, commissioning will include the following specific activities:

.3 Review of shop drawings for commissionable mechanical and electrical equipment and systems at the same time as the design engineers. Comments from the Commissioning Agent (CxA) will be given to the design engineers to incorporate into their review as appropriate. Contractors will respond to the comments from the engineer of record.

.4 Verify equipment is installed in accordance with the manufacturer's recommendations, comply with TGS Version 30.0 requirements and industry accepted standards including review of completed manufacturers' start-up sheets, supplemented where required with commissioning installation verification checklists provided by the CxA. Contractor shall complete check sheets as required by the CxA.

.5 Verify equipment is set-up, adjusted and balanced to perform as specified. This will include review of Testing, Adjusting, and Balancing (TAB) procedures, review of TAB reports and spot checking measurements on site. The TAB contractor shall cooperate with the CxA providing information requested and tools and manpower for spot checking measurements as required by the CxA.

.6 Functional Performance Testing (FPT) of mechanical and electrical equipment and systems to ensure proper, complete and efficient operation under the range of conditions they are expected to encounter. Contractors shall provide manpower, tools and other services as required by the CxA to perform the FPT.

.7 CxA will review O&M documentation provided to the owner to ensure it is complete, comply to TGS Version 3.0 requirements and acceptable for ongoing operation and maintenance of the equipment. The review shall be sent to the consultant for incorporation with his comments. The Contractors shall provide changes as required by the Engineer.

.8 The CxA will witness the Owner's operating personnel training to verify it was adequate and complete to ensure they fully understand the requirements of operating and maintaining the equipment. Contractors shall ensure training meets the approval of the CxA and provide additional training if requested. An Operating and Maintenance Manual (O&M) should be prepared by the contractor for CxA reviews before conducting training to operating personnel.

.9 Commissioning does not take away from, reduce responsibility of or in any way diminish the requirement for system designers and installing contractors to provide a complete, finished and fully functioning product.

1.7. Coordination

.1 Commissioning Team. The following contractors will be required to participate in commissioning and to assist the commissioning team with verification, testing and documentation preparation:

.1 General Contractor (GC or Contractor)

.2 Construction Manager (CM)

.3 Contractor (MC)

.4 Electrical Contractor (EC)

.5 Testing, Adjusting and Balancing contractor (TAB)

.6 Controls Contractor (CC)

.7 Contractors installing insulation, windows and doors, air barrier or other building shell components.

.2 Any other installing Subcontractors or suppliers of equipment.

.1 Other members of the commissioning team include:

.2 Commissioning Agent (CxA)

.3 Owner's Project Manager (PM)

.4 Designated representative of the owner's Operations and Maintenance personnel(O&M).

.5 Architect and Design Engineers - particularly the mechanical and electrical engineer (A/M/E).

.3 Management: Contractors shall cooperate fully with the CxA who will be the Owner's representative for commissioning during all commissioning activities. Contractors shall work together and with the other members of the commissioning team as required to fulfil their contracted responsibilities and meet the objectives of commissioning.

.4 Scheduling: The GC/CM will work with the CxA to schedule the commissioning activities required of contractors and subcontractors. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

.5 The CxA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. As construction progresses more detailed schedules may be developed by the GC/CM.

.6 The GC/CM shall be responsible for ensuring that the mechanical, electrical, and controls sub-contractors will return to the building during seasonal testing (at least 2 full day site visits) after the start of the warranty period to review system operation and to address operational issues.

1.8. Responsibilities

.1 Mechanical Contractor:

.1 Attend initial commissioning coordination meeting.

.2 Provide a complete set of all submittals for mechanical equipment for the CxA.

.3 Provide complete equipment and systems start-up including personnel and tools, as required for safe, proper and complete start-up of all mechanical equipment.

.4 Perform installation verification, start-up and complete required documentation as directed by CxA.

.5 Correct all deficiencies found during installation verification, start-up and TAB to ensure that all equipment and systems are fully functional and ready for functional performance testing.

.6 Prepare O&M manuals and supplementary information on all equipment as directed by CxA and assemble in binders tabbed and indexed. Supplementary information may include, but is not limited to, such items as power/control field wiring diagrams, equipment maintenance schedule, vendor and maintenance contact lists. Submit to CxA when requested.

.7 Prepare preliminary schedule for O&M manuals submission, owner training, pipe and duct system testing, flushing and cleaning, equipment start-up, and TAB for use by the CxA. Update schedule throughout the construction period.

.8 Notify CxA a minimum of two weeks in advance of equipment and system start-up and/or installation verification testing.

.9 Set-up and schedule vendors and contractors required to participate in the owner training sessions for all equipment and systems.

.10 Provide a complete set of as-built record drawings and schematics, include a copy to the CxA.

.11 Return to site with the GC/CM, O&M and CxA during seasonal testing (at least 2 full day site visits) after the start of the warranty period to review system operation and to address operational issues.

.2 TAB Contractor(s)

.1 Attend initial commissioning coordination meeting.

.2 Submit TAB procedures to CxA and Mechanical Consultant for review and acceptance.

.3 Provide a preliminary TAB report showing that the system is complete and capable of being balanced. Provide an additional copy of the preliminary report labelled “For CA”.

.4 Attend TAB review meeting scheduled by the CxA. Be prepared to discuss procedures that shall be followed in TAB and findings of preliminary TAB.

.5 Submittal of final TAB report showing all flows, pressures, motor speeds, voltages and amperages etc., as required for a full and complete balancing report on all systems. Provide an additional copy of the TAB final report labelled “For CxA”, and include as-built distribution systems schematics.

.6 Participate in verification of the TAB report, which includes of repeating selected measurement contained in the TAB report where required by the CxA for verification or diagnostic purposes.

.3 Building Controls and Automation System Contractor(s)

.1 Attend initial commissioning coordination meeting.

.2 Attend Sequence of Operation and Graphics review meeting scheduled by the CxA. Be prepared to discuss all sequences including all changes, and provide a schematic for each proposed graphic.

.3 Provide the following submittals to the CxA at time of FPT. (Note: The following shall be updated to as-built conditions).

.4 Hardware and software submittals and shop drawings.

.5 Narrative description of each control sequence for each piece of equipment or system controlled.

.6 Point-to-point and sensor calibration verification checklists

.7 As-built diagrams showing all control points, sensor locations, point names, actuators, controllers and, where necessary, points of access, superimposed on diagrams of the physical equipment.

.8 Printout of panel layouts including all analog input, analog output, digital input, and digital output connections. Provide a separate list for each standalone control unit.

.9 Printout of final control programming algorithms, include current values of all parameters for each system point.

.10 Owners operation and maintenance manuals.

.11 Provide complete training to operating personnel on hardware, operation and programming, and the application program for the system.

.12 Demonstrate system performance to CxA. including all modes of system operation. (e.g. normal, abnormal, emergency).

.13 Provide control system technician to operate systems as required by and under the direction of the CxA during system verification and functional performance testing.

.14 Provide support and coordination with TAB contractor on all interfaces between their scopes of work. Provide all devices, such as portable operators' terminals, for TAB use in completing TAB procedures.

.15 Provide any trend logs as may be required by the CxA.

.16 Return to site with the GC/CM, O&M and CxA during seasonal testing (at least 2 full day site visit) after the start of the warranty period to review system operation and to address operational issues.

.4 Electrical Contractor

.1 Attend commissioning meetings scheduled by the CxA.

.2 Provide a complete set of all submittals for electrical equipment to the CxA

.3 Correct all deficiencies found during Installation Verification Inspection (IVI), start-up, TAB and FPT to ensure all equipment and systems are fully functional and in complete and proper working order.

.4 Prepare O&M manuals and supplementary information on all equipment as directed by CxA and assemble in binders tabbed and indexed. Supplementary information may include, but is not limited to, such items as power/control field wiring diagrams, equipment maintenance schedule, vendor and maintenance contact lists. Submit to CxA when requested.

.5 Provide electrical system technicians to assist during system verification and functional performance testing as required by the CxA.

.6 Provide a complete set of as-built record drawings and schematics with a copy to the CxA.

.7 If needed, return to site with the GC and CxA during seasonal testing to make necessary adjustments/corrections on the electrical systems after the start of the warranty period to review system operation and to address operational issues.

.5 Emergency Power Distribution System Components Contractors

.1 Systems include, but are not limited to:

.1 Fuel Oil Handling system

.2 Transfer Switch(es)

.3 Generator Set (s)

.4 Instrumentation

.5 Controls

.2 Submit testing procedures to the CxA and Electrical Consultant for review and acceptance, complete with pre-testing and coordinated testing of all emergency power distribution system components.

.3 Coordinate with the CxA and Electrical Consultant in order that they may witness the coordinated testing.

.4 Attend testing review meeting scheduled by the CxA. Be prepared to discuss testing procedures.

.5 Submit all documents related to each component's testing. Provide additional copies to the CxA.

1.9. Equipment/Systems to be commissioned

.1 Systems to be commissioned under this part are primarily associated with HVAC for the building and central plant but do not include process or special purpose equipment such as:

.1 life safety systems such as fire alarm, sprinkler, fire pumps

.2 security systems such as card readers, automatic door locks, CCTV cameras

.3 Communication systems such as data, paging and telephone systems

.2 All major mechanical equipment and their controls will be commissioned using a series of installation verification and functional checks. Equipment to be commissioned during the course of this project includes new systems but are not limited to:

.1 Building Automation System (Controls System)

.2 Water to Water Heat Pumps

.3 Water to Air Heat Pumps

.4 Heat Recovery Unit

.5 Domestic Water Heater (Including Pre-Heat System)

.6 Geothermal Circuit Circulation Pumps

.7 Heat Pump Circuit Circulation Pumps

.8 PV/T Re-circulation Pumps

.9 Exhaust Fans

.10 Force Flow Heaters

.11 Heat Exchangers

.12 Piping Systems

.13 Ducting Systems

.14 Auxiliary Heating System

.15 VFDs

.16 Other major equipment as may be included in construction but may have been left off this list will also be required to be included in commissioning.

2 Part 2 - Products

2.1 Testing Equipment

.1 All standard testing equipment required to perform start-up and installation verification and required functional performance testing shall be provided by the division contractor for the equipment being tested.

.2 Special test equipment, tools or instruments required by the contract documents shall be provided for commissioning and shall be left on site.

.3 All testing equipment shall have had a certified calibration, traceable to a national standard, performed within the past year. If not otherwise noted, temperature sensors and digital thermometers shall have an accuracy of ± 0.1°F, pressure sensors shall have an accuracy of ± 1.0% for each range available on the instrument (not the full range of the meter). All equipment shall be re-calibrated when dropped or damaged.

3 Part 3 - **Execution**

3.1 Meetings

.1 Commissioning Meetings: Soon after construction commences, the CxA will conduct an initial commissioning scoping meeting with the entire commissioning team in attendance. Commissioning requirements, procedures, responsibilities and schedule will be reviewed.

.2 Other commissioning meetings will be conducted as required throughout construction. These meetings will cover coordination, deficiency resolution and planning issues with particular Contractors and Subs.

3.2 Submittals

.1 Division 21 through 28 Contractors and Subs shall supply one (1) copy of all shop drawings marked “for CxA” to the CxA at the same time as provided to other designers for review, including all controls and shop drawings and narrative description of each control sequence for each piece of equipment or system controlled.

.2 Contractors and Subs shall comply with specific requests for submittal documentation from the CxA in a timely fashion to ensure commissioning work continues as scheduled. At a minimum, the request will include the manufacturer’s printed installation and start-up procedures, O&M data and manuals, final shop drawings, power and control field wiring drawings, sequences of operation, and results of required tests.

.3 Final completion of the O&M manuals including all required submittals is the responsibility of the Contractor. The CxA will review and forward comments to the engineer of record for follow-up.

.4 TAB contractor shall supply an extra copy of the preliminary and the final TAB report marked “for CxA” for review. The CxA will review and forward comments to the engineer of record for follow-up.

.5 Contractor shall provide an extra set of O&M manuals, as built drawings and field power wiring diagrams to the CxA. The CxA will review and forward comments to the engineer of record for follow-up.

3.3 Start-up and installation verification checks

.1 The installing Contractor or Sub-contractor shall be responsible for performing and documenting start-up based on manufacturer's requirements and/or good industry practice. They shall perform all required procedures and checks and document the results. Start-up documents as requested by the CxA shall be provided.

.2 Controls and Sensor Point-to-Point Checks. Control system point-to-point checks and calibration checks for all sensors shall be included as part of installation verification. The results shall be documented and provided to CxA.

.3 Execution of Start-up and Installation Verification (IV/S-U).

.1 IV/S-U checklists shall be developed and provided by CxA. Where appropriate manufacturers checklists and procedures shall be combined or accepted in lieu of CxAs checklists.

.2 The contractor, sub-contractor, manufacturer's rep or supplier shall perform IV/S-U. They shall complete the checklist on each piece of equipment. IV/S-U shall be successfully completed prior to any FPT.

.3 At his sole discretion the CxA shall observe, recheck or verify the IV/S-U documentation of any or all equipment. The contractor shall cooperate with and provide support to the CxA as requested.

.4 Only individuals with direct knowledge of and who personally witnessed any IV/S-U shall sign off the checklists.

.5 It will be the responsibility of the contractor to remedy all deficiencies found. Retesting by the contractor may be required to demonstrate corrections have been made.

.4 Deficiencies, Non-Conformance and Approval of IV/S-U Checklists.

.1 Dates for remedy of deficiencies shall be provided to the CxA with the initial IV/S-U documents.

.2 The CxA will work with all parties as required to affect proper corrective measures, correct and retest deficiencies or uncompleted items.

.3 Items left incomplete or not properly corrected, causing delays or multiple call-backs for retest may result in back-charges to the party at fault.

3.4 TAB (Testing, Adjusting and Balancing)

.1 A preliminary TAB balancing shall be done prior to final balancing. System deficiencies requiring correction prior to final TAB shall be documented.

.2 All deficiencies shall be corrected by the contractor prior to final balancing.

.3 Participate in repeating selected measurement as required by the CxA for verification or diagnostic purposes.

3.5 Functional Performance Testing (FPT)

.1 In general, functional performance testing is conducted after IV/S-U have been satisfactorily completed, the control system is fully operational, and TAB is complete.

.2 The installing Contractor or Sub-contractor, under the direction of the CA, shall execute all FPT and shall maintain responsibility for all equipment tested.

.3 In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part-load, full-load). Proper responses to such modes and emergency conditions (e.g., power failure, freeze condition, no flow, equipment failure, etc.) shall be verified.

.4 FPT verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers. The CxA will determine which method is most appropriate.

.5 The CxA will schedule FPTs through the GC/CM and affected Contractors and Subs.

.6 Corrections of minor deficiencies identified during FPT may be made by the Contractor or Sub during the tests.

.7 Where a deficiency cannot be corrected immediately, the Contractor or Sub shall provide a reasonable timeline for correction. The CxA shall document the deficiency and reschedule the FPT.

.8 Where there is a dispute regarding whether a problem is a deficiency or who is responsible, the deficiency shall be documented and resolution attempted by parties in attendance. Final acceptance of proposed resolution lies with the Owner or designated representative.

.9 The burden of responsibility to solve and correct deficiencies lies with the A/M/E, manufacturers, vendors, GC/CM, Contractors, and Subs. The CxA may recommend solutions to problems in consultation with these parties.

.10 Cost of Retesting:

.1 If the Contractor or Sub is responsible for a deficiency then they shall carry the cost to rework the deficiency and complete the IV/S-U or FPT.

.2 The CxA will direct the first retesting of the equipment at no charge.

.3 If corrections of deficiencies have been reported to be successfully completed but are determined during testing to be faulty or otherwise incomplete, the time for the CxA to direct second or subsequent retests will be charged back.

3.6 Training of Owner Personnel

.1 The contractor supplying each piece of equipment shall be responsible for providing complete and satisfactory training on that piece of equipment. Training may be performed by the contractor, supplier, manufacturer or others as the contractor may decide best able to provide that training.

.2 Owner personnel shall be provided with completed O&M Manuals at least 1 week prior to training. In addition, up to five (5) copies of the related maintenance booklet and wiring as-builts shall be provided to owner personnel for the purpose of training.

.3 The GC shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed. The CxA shall be responsible for overseeing and approving the content and adequacy of training for all commissioned equipment.

.4 Basic training for each piece of equipment shall include the following items at a minimum:

.1 General description of the system and its operation (Design Intent)

.2 Detailed itemization and identification of major components and access to same

.3 Detailed itemization and identification of operating controls and safeties including normal and abnormal sensor readings

.4 Review of the O&M manuals for identification of service requirements, procedures, wiring diagrams, parts identification, safety procedures, etc.

.5 Review of system drawings and schematics

.6 Review of control drawings and schematics

.7 Operational review for

.1 Start-up

.2 Normal operation

.3 Shut down

.4 Unoccupied operation

.5 Seasonal changeover

.6 Manual operation

.7 Controls set-up and programming

.8 Troubleshooting and alarms

.9 Interactions with other systems

.10 Adjustments and optimizing methods for energy conservation

.11 Health and safety issues

.12 Regular maintenance requirements including frequency, parts and equipment, and tools needed, replacement parts sources

.13 Special maintenance needs

.14 Tenant interaction issues

.15 Discussion of environmentally responsible system features

.16 Identification of contacts for service support and maintenance parts

3.7 Deferred Testing

.1 If any check or test cannot be completed due to weather conditions, the building structure, required occupancy condition or other deficiency, execution of IV/S-U and/or FPT may be delayed upon approval of the Owner.

3.8 Post-Occupancy Review

.1 The CxA, GC/CM, mechanical, electrical, and controls sub-contractors shall return to the building approximately 10 months after the start of the warranty period to review system operation, owner concerns, unresolved deficiencies or warranty issues and to address any outstanding operational issues.

.2 The exact date and time of this meeting is to be coordinated by the CxA.

.3 CxA will provide site report to the consultants and owner for review, acceptance and formal issue to the appropriate parties.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Do thermal insulation in accordance with Measures for Energy Conservation in New Buildings, Associate Committee of the National Building Code (ACNBC).

.2 Meet NFPA 90A-1985. Maximum flame spread rating of 25 and maximum smoke developed rating of 50 in accordance with NFPA 255-1984 and CAN4-S102-M83 for all components of insulation system. Materials tested in accordance with ASTM C411-82..

1.2 Scope of Work

.1 All piping as listed and installed as part of this project to be insulated in accordance with this section unless specifically stated otherwise.

.2 Piping to be insulated:

.1 Domestic hot water.

.2 Domestic cold water.

.3 Domestic water, recirculation.

.4 Thermofluid heating systems piping supply and return.

.5 All rain water piping, horizontal and vertical upto connections to buried main drains.

.6 Supply to and from humidification system, all mechanical equipment drains.

.7 Horizontal runs of all above grade exposed sanitary piping.

.8 Drains from all fresh air intake ducts.

.9 All condensate drains from equipment.

.10 Other services as specified and as noted on drawings.

1.3 Shop Drawings

.1 Submit shop drawings in accordance with Section 21 05 01.

.2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for pipe, fittings, valves and jointing recommendations.

1.4 Samples

.1 Submit for approval sample of complete insulation assembly for the following:

.1 concealed pipe and fittings

.2 exposed pipe and fittings

1.5 Definitions

.1 For purposes of this section:

.1 "CONCEALED" - insulated mechanical services and equipment in hung ceilings and non-accessible chases and furred spaces.

.2 "EXPOSED" - will mean "not concealed" as defined herein.

1.6 Inspection Procedures

.1 Do not apply insulation or identification marking until installed work has been approved by the Engineer.

.2 Do not enclose concealed work until the insulation and identification marking has been approved by the Engineer.

PART 2 - PRODUCTS

2.1 Heating and Cooling Piping (P-1)

.1 Concealed Piping and Fittings:

.1 Piping:

Fiberglas Canada MP-101 with All Service Jacket, installed according to MPS-108.

.2 Fittings:

Glass fibre blanket conforming to CGSB #51-FP11 compressed to same thickness as adjoining insulation and secured with jute twine. Over this apply a smooth coat of insulating cement and recover with 4 oz. canvas neatly pasted on with fireproof adhesive.

.2 Exposed Piping and Fittings:

.1 Piping:

Fiberglas Canada MP-101 with All Service Jacket, installed according to MPS-108. Provide PVC jackets on all exposed piping.

.2 Fittings:

Glass fibre blanket conforming to CGSB #51-FP11 compressed to same thickness as adjoining insulation and secured with jute twine. Over this apply a smooth coat of insulating cement and recover with 115 g canvas neatly pasted on with fireproof adhesive. Provide PVC jackets on all fittings.

.3 Application: for piping valves and fittings on:

.1 Condensate from heat pumps, heat recovery units, fresh air intake ducts, and all other mechanical equipment having drains.

.2 All ground source piping systems, supply and return, within the building.

.3 Domestic hot water.

.4 Domestic hot water recirculation.

.5 Steam supply lines in humidification system.

.6 Tempered water supply.

.7 All fittings such as strainers, valves, etc.

.4 Thickness

.1 38mm (1-1/2") for:

.1 heating piping systems, all pipe sizes, 32mm (1-1/4”) and above.

.2 domestic water piping, all pipes 65mm (2-1/2”) and above.

.3 25mm (1”) for all other services, all pipes, all sizes except noted in item 4 below.

.4 Piping penetrating the building envelope.

2.2 Cold and Dual Temperature Media Piping (P-2)

.1 Concealed Piping and Fittings:

.1 Piping:

Fiberglas Canada MP-101 with All Service Jacket, installed according to:

.1 MPS-102 for domestic cold water, make-up piping to equipment.

.2 MPS-109 for rainwater leaders, exposed sanitary piping, drains from humidifiers.

.3 MPS-102 for cold water supply to humidifiers.

.2 Exposed Piping and Fittings:

Same as concealed, with 170g canvas jacket and saturated with approved lagging adhesive. Provide PVC jackets on all exposed piping and fittings.

.3 Application: for piping, valves and fittings on:

.1 Domestic cold water.

.2 Horizontal and vertical runs of rainwater leaders and piping to ground floor upto connections to buried storm drains.

.3 Cold water piping to humidification system.

.4 Make-up water piping to equipment.

.5 Horizontal runs of all above grade exposed sanitary piping.

.6 Drain piping from humidifiers.

.4 Thickness

.1 38mm (1-1/2") for:

.1 domestic cold water, all pipes, 65mm (2-1/2”) and above.

.2 25mm (1") for all other services, all pipes, all sizes except for piping connected to roof drains shall be insulated with 100mm (4”)

2.3 Flexible Mineral Fiber with Vapour Barrier to 85C (P-3)

.1 Application on:

.1 Underside of roof drain body.

.2 Material:

.1 CGSB 51-GP-11M+Amdt-Apr-78, mineral fiber blanket for piping and CGSB 51-GP-52M vapour barrier jacket and facing material.

.3 Thickness: all sizes, 100mm (4").

2.4 Fastenings

.1 For insulation systems P-1 and P-2:

.1 Tape: self adhesive.

.2 Lap seal adhesive: quick-setting for joints and lap sealing of vapour barriers.

.1 Acceptable material: Foster 87-75 asbestos free at 6m2/L.

.3 Lagging adhesive: fire retardant coating.

.1 Acceptable material: Foster 30-60 asbestos free at 1.25 m2/L.

.2 For insulation system P-3 and underside of roof drain body:

.1 Contact adhesive: quick-setting for seams and joints.

.2 Tape: self adhesive PVC.

.1 Acceptable material: Armstrong, Foster 85-20 asbestos free at 5m2/L.

2.5 Insulation Cement

.1 To CAN/CGSB-51.12-M86.

2.6 Jackets

.1 Canvas.

.1 ULC listed plain weave, cotton fabric at 220 g/m^2.

.2 Acceptable materials:
Alpha Maritex 3451-RW

Clairmount Diplag 60
S. Fattal Thermocanvas

.2 PVC.

.1 Apply in accordance with CGSB 51-GP-53M.

.2 Fitting covers, one piece, premoulded to match.

.3 Fastenings standard to manufacturer.

.4 Must be ULC approved.

2.7 Fittings, Valves, Strainers and Joints of Grooved Piping Systems

.1 Wrap with glass fibre blanket to thickness equal to that of adjoining insulation and jacket with premoulded PVC fitting covers secured over insulation by banding or taping ends to adjacent pipe covering with vapour barrier tape.

PART 3 - EXECUTION

3.1 General

.1 Insulation shall be continuous through all sleeves.

3.2 Application

.1 Insulation and surfaces shall be clean and dry when installed and during application of any finish. Apply insulation materials, accessories and finishes in accordance with manufacturer's recommendations and as specified herein.

.2 Insulation on roof drain body held in place with 100% coverage of adhesive.

.3 On piping with insulation and vapour barrier, install high density insulation under hanger shield. Maintain integrity of vapour barrier over full length of pipe without interruption at sleeves, fittings and supports.

3.3 Installation

.1 Preformed: sectional up to NPS 12, sectional or curved segmented above NPS 12.

.2 Multi-layered: staggered butt joint construction.

.3 Vertical pipe over NPS 3: insulation supports welded or bolted to pipe directly above lowest pipe fitting. Thereafter, locate on 4.5m centres.

.4 Expansion joints in insulation: terminate single layer and each layer of multiple layers in straight cut at intervals recommended by manufacturer. Leave void of 25mm between terminations. Pack void tightly with mineral fiber.

.5 Seal and finish exposed ends and other terminations with insulating cement.

.6 Expansion joints in piping: provide for adequate movement without damage to insulation or finishes.

.7 Mounting flanges, unions and equipment, expansion joints, valves, other components requiring regular maintenance. Provide neatly cut removable sections of insulation with stainless steel clamps on either side.

.8 Insulation is not required for:

.1 Chrome plated piping, valves and fittings.

3.4 Fastenings

.1 Secure pipe insulation by tape at each end and center of each section, but not greater than 900m on centers.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

.1 Shop **Drawings/Product Data:** Submit shop drawings/product data sheets to the regulatory authority for review and approval prior to submitting to the Consultant. Conform to the following requirements:

.1 Shop drawings/product data sheets are to include all products specified in this Section except pipe and fittings, each clearly marked to indicate exactly what is being supplied.

.2 Submit complete CAD white print layout drawings indicating source of water supply with pipe size and test flow and pressure, "head-end" equipment piping schematic, pipe routing and sizing, and risers, all signed and sealed by a qualified P. Eng. as specified below.

.3 Submit copies of all calculations signed by the same P. Eng. who signs the layout drawings, and a listing of all design data used in preparing the calculations, system layout and sizing.

.2 **Installer Qualifications:** Immediately after award of Contract, submit the name of the fire protection company proposed for the work, with documentation to confirm that the company conforms to requirements of this Section of the Specification.

.3 **Weekly Inspection Reports**: Submit copies of the system design P. Engineer's weekly inspection reports as specified below.

.4 **Grooved Coupling Site Inspection Reports**: Submit site inspection reports from the grooved coupling Manufacturer's representative as specified in Part 3 of this Section.

.5 **Test Certificate:** Submit completed NFPA system material and test certificate(s) as specified in Part 3 of this Section.

1.02 QUALITY ASSURANCE

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

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

.2 CSA B137.2, PVC Injection-Molded Gasketed Fittings for Cold-Water Pressure Services.

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

.4 ASTM A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.

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

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

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

.2 **Site Personnel:** All site personnel are to be Sprinkler and Fire Protection Installers licensed in the jurisdiction of the work and under the continuous supervision of a foreman who is a journeyman. The ratio of Journeyman to Apprentices is to be in accordance with requirements of the Ontario College of Trades.

.3 **System Installer:** The system installer is to be an experienced fire protection system company and a member in good standing of the Canadian Automatic Sprinkler Association with a minimum of five years of experience installing fire protection systems in a complex equal to this Project and is to be certified to ISO 9001 and CSA-W47.1 for welding.

.4 **Dimensions and Coordination:** Check and verify all dimensions and conditions at the site and ensure that the work can be performed as indicated. Co-ordinate work with all trades at the site and accept responsibility for and the cost of making adjustments to piping and/or spacing to avoid interference with other building components.

.5 **Weekly Inspection Reports:** The P. Eng. who stamps and signs the design shop drawings and system calculations is to conduct weekly site inspections for quality control and prepare and submit an inspection report after each site inspection.

.6 **Manufacturer:** All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer; grooving tools shall be of the same manufacturer as the grooved components.

.7 **Grooved System Fitting Inspections:** A Manufacturer's factory-trained representative shall periodically visit the job site and visually inspect grooved piping fitting installation for best practices as specified in Part 3 of this Section. All system components must be UL and/or ULC listed and labelled, and FM approved.

1.03 DESIGN REQUIREMENTS

.1 **System Designer**: Fire protection work is to be designed by a fully qualified mechanical P. Eng. registered and licensed in the jurisdiction of the Project. Refer to the mechanical work Section entitled Mechanical Work General Instructions for requirements governing the employment of the Engineer.

.2 **Water Flow and Pressure Test Data:** If water supply flow and pressure test data is not available, conduct Municipal main water flow and pressure tests at the nearest fire hydrant to obtain criteria to be used in system design. Include the hydrant location and flow and pressure test data with system design calculations.

.3 **Sprinkler System Design Criteria**: Fire protection sprinkler work is to be designed in accordance with NFPA 13 and Provincial Standards, and, where required, local building and fire department requirements and the standards of the Owner's Insurer.

.4 **Sprinkler System Occupancy – Hazard Design requirements:** As per NFPA 13 occupancy-hazard density requirements, unless otherwise specified.

.5 Sprinklers heads shall be referred to on drawings, submittals and other documentation, by the sprinkler identification or Model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

2 PRODUCTS

2.01 PIPE, FITTINGS AND JOINTS

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

.1 **Below-grade Water Service:** Class 200 PVC, DR14, rigid hub and spigot pattern PVC pipe and CSA certified fittings to CAN/CSA B137.2 and B137.3, complete with gasketed joints.

.2 **Schedule 40 Black Steel – Grooved Coupling Joints:** North American produced Schedule 40 mild black carbon steel, ASTM A53, Grade B, complete with fittings and couplings equal to Victaulic "FireLock" fittings and Installation-Ready Victaulic Style 107N and 009N rigid coupling joints. Strap-on fittings such as Victaulic "Snap-Let" strap type fittings are not acceptable.

.3 **Schedule 40 Black Steel – Screwed and Welded Joints:** North American produced Schedule 40 mild black carbon steel, ASTM A53, Grade B. Screwed piping is to be complete with Class 125 cast iron screwed fittings to ANSI/ASME B16.4. Welded piping is to be complete with factory made seamless carbon steel butt welding fittings to ASTM A234, Grade WPB, **long sweep pattern wherever possible**.

.4 **Schedule 40 Galvanized Steel:** As specified above for black steel pipe and fittings but hot dipped galvanized.

.5 **Black Steel Grooved Joint Couplings:** Two ductile iron housing segments to ASTM A536, Grade 65-45-12; pressure responsive elastomer gasket, and ASTM A449 compliant bolts and nuts.

.1 Rigid Type: Housings cast with offsetting, angle-pattern, bolt pads to provide system rigidity and support and hanging in accordance with NFPA-13, fully installed at visual pad-to-pad offset contact. (Couplings that require exact gapping at specific torque ratings are not permitted.)

Installation-ready for complete installation without field disassembly. Standard of Acceptance: Victaulic Style 009N.

.2 Flexible Type: For use in locations where vibration attenuation and stress relief are required: Standard of Acceptance: Victaulic Installation-Ready Style 177 or Style 77.

.3 Installation-Ready™ fittings for grooved end steel piping in fire protection applications sizes NPS 1-¼ thru 2½ (DN 32 thru DN 65). Fittings shall consist of a ductile iron housing conforming to ASTM A-536, grade 65-45-12, with installation-ready™ ends, enamel coated. Fittings complete with pre-lubricated grade “E” EPDM type ‘a’ gasket; and ASTM A449 electroplated steel bolts and nuts. System shall be UL listed for a working pressure of 300 psi (2065 kPa) and FM approved for working pressure 365 psi (2517 kPa).

.4 Schedule 40 fittings to match Schedule of pipe.

.6 **Galvanized Steel Grooved Joint Couplings:** As specified above for black steel fittings but hot dipped galvanized.

.7 **Flexible Pipe:** Victaulic Vic-Flex flexible metallic hose sprinkler head connections, each complete with an open-gate attachment bracket, may be used in lieu of rigid pipe offsets or return bends for sprinkler drops. The drop system shall consist of a braided type 304 stainless steel flexible tube, zinc plated steel Male threaded nipple or Victaulic FireLock IGS Groove Style 108 coupling for connection to branch-line piping, and a zinc plated steel reducer with a female thread for connection to the sprinkler head.

.1 The drop shall include a UL approved Series AH1 with 3” bend radius; AH2 or AH2-CC braided hose with a bend radius to 2” to allow for proper installation in confined spaces.

.2 Union joints shall be provided for ease of installation.

.3 The flexible drop shall attach to the ceiling grid using a one-piece open gate Series AB1 or AB2 bracket. The bracket shall allow installation before the ceiling tile is in place.

.4 The braided drop system is UL listed for sprinkler services to 175 psi (1206 kPa) and FM Approved to 200 psi (1380 kPa).

.5 Acceptable products are:

.1 Victaulic Vic-Flex

.2 FlexHead Industries

.3 The Metraflex Co. “FireDrop”

2.02 SERVICE MAIN DOUBLE CHECK DETECTOR VALVE ASSEMBLY

.1 Minimum 1205 kPa (175 psi) rated dual torsion thermoplastic and stainless-steel spring check valve backflow preventer assembly with replaceable seats to CAN/CSA B64, complete with a stainless-steel body, top access cover, OSY inlet and outlet shut-off valves with pipe connection ends to suit the system header piping, and by-pass water meter (GPM) with test cocks and by-pass double check valves.

.2 Acceptable manufacturers are:

.1 Apollo

.2 Watts

.3 Febco

.4 Wilkins

2.03 SHUT-OFF VALVES

.1 Minimum 2065 kPa (300 psi) rated full port brass or bronze body grooved or screwed ball valves and lug body or grooved end type butterfly valves:

.1 Butterfly valve seat shall be pressure responsive, with stem offset from the disc centreline to provide complete 360-degree circumferential seating.

.2 Weatherproof actuator housing with handwheel and supervisory switches.

.3 Standard of Acceptance: Victaulic Series 728 (ball valve) and 705 (butterfly valve).

2.04 CHECK VALVES

.1 Minimum 1725 kPa (250 psi) resilient seat check valves tapped for site installation of a 20 mm (¾") dia. ball drip, stainless steel spring and shaft, suitable for vertical or horizontal installation. Standard of Acceptance: Victaulic Series 717.

2.05 BALL DRIP

.1 Equal to National Fire Equipment Ltd. Model #58-2, 20 mm (¾") diameter automatic ball drip.

2.06 SHUT-OFF VALVE SUPERVISORY SWITCHES

.1 Tamper-proof supervisory switches in a weatherproof actuator housing, each arranged to activate a fire alarm system trouble alarm condition if the valve is closed or tampered with, each suitable in all respects for the application, and with each complete with all required mounting and connection hardware. Standard of Acceptance: System Sensor.

2.07 FIRE DEPARTMENT CONNECTION

.1 Wall mounting polished brass clapper type dual inlet Fire Department connection with two 65 mm (2½") diameter inlets threaded to Fire Department hose requirements and equipped with caps and chains, an outlet sized as shown, and a faceplate.

.2 The faceplate is to be polished brass and complete with "STANDPIPE", “AUTO SPKR”, or both “STANDPIPE” and “AUTO SPKR” cast-in raised lettering, as required.

.3 At the low point near each fire department connection, install a 90-degree elbow with drain connection to allow for localized system drainage to prevent freezing. Standard of Acceptance: Victaulic #10-DR.

2.08 DRY PIPE ZONE VALVE

.1 Dry pipe valve complete with basic trimmings, and the following:

.1 Accelerator quick opening device.

.2 Priming Chamber Attachment to allow the priming level to be maintained while the system remains pressurized.

.3 A Fill Line Attachment to provide a source of water for maintaining the prime level.

.4 An Automatic air pressure maintenance device.

.5 Electrical alarm switch.

.6 Acceptable Products are:

.1 Victaulic Series 768N, with Series 746 accelerator quick opening device.

.2 Reliable model D, with model B1 accelerator quick opening device.

2.09 DRY PIPE ZONE AIR COMPRESSOR

.1 Equal to a Reliable Model A, Victaulic Model 7C7, or General Air Products OL Series CSA certified, 115-volt, 1 phase oil-less, direct driven compressor with a motor conforming to requirements specified in the mechanical work Section entitled Basic Mechanical Materials and Methods, and a pipe mounting bracket.

.2 Compressor set capacity and performance must suit the final dry pipe standpipe system design and reviewed piping shop drawings. If a larger compressor set than that specified is required, provide the larger set at no additional cost, and include any additional costs for a larger size motor starter and associated wiring.

2.10 DRUM DRIPS

.1 Equal to AGF Manufacturing Inc. Model 5200 “COLLECTandDRAIN” double ball valve anti-trip type drum drips with an identified red instructional plate, or The Metraflex Co. “Never-Tip” single valve assembly with sight glass.

2.11 WATER FLOW ALARM SWITCH

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

2.12 ALARM CHECK VALVE

.1 Enamelled cast iron check valve assembly designed for either vertical or horizontal mounting and to actuate alarms when the wet type sprinkler system is activated. The assembly is to be minimum 1205 kPa (175 psi) cold water rated with all moving parts constructed of brass, bronze, stainless steel or EPDM, and is to be complete with:

.1 Pipe fittings and accessories for site connection of an excess pressure pump.

.2 Basic trim including piping materials and check valve for an external by-pass, potable water supply and system water supply pressure gauges with gauge test ports and shut-off valves, an angle type main drain valve, and fittings for mounting an alarm test by-pass.

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

.4 Alarm trim with pipe and fittings for connection to a water motor alarm, and an adjustable pressure switch for electrical connection to an alarm system upon flow through the valve.

.2 **Smoke Detectors**: Dual chamber ionisation type smoke detectors, each complete with a red LED that pulses during normal standby conditions and illuminates steadily during an alarm condition.

.3 **Pull Station**: Surface wall mounting (to a recessed box) non-break glass pull station with test/reset key.

2.13 SPRINKLER ZONE CONTROL RISER MODULES

.1 Equal to Victaulic Co. "FireLock" Series 747M factory assembled zone control riser modules, each complete with a painted cast ductile iron grooved end body, a ball type shut-off valve, a test and drain combination with properly sized orifice, a flow alarm switch, a pressure gauge with cock, and a pressure relief valve kit.

2.14 SPRINKLER HEADS

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

.2 Sprinklers shall be glass bulb type, with hex shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation.

.3 Wrenches shall be provided by the sprinkler manufacturer that directly engage the hex-shaped wrench boss integrally cast in the sprinkler body.

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

.5 Where exposed pendent heads occurs in areas with suspended ceilings, they are to be complete with chrome plated escutcheon plates. Similarly, sidewall heads with concealed piping are to be complete with chrome plated escutcheon plates.

.6 Sprinkler heads which are exposed in areas where they may be subject to damage are to be complete with wire guards, chrome plated where in finished areas.

.7 Sprinkler heads located in areas or over equipment where high ambient temperature is present are to be, unless otherwise specified, 74° C (165° F) heads. All other heads, unless otherwise specified or required, are to be 57° C (135° F) rated.

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

.9 Acceptable sprinkler head manufactures are:

.1 Tyco Fire Suppression & Building Products

.2 Victaulic Co.

.3 The Viking Corporation

.4 The Reliable Automatic Sprinkler Co.

2.15 SPARE SPRINKLER HEAD CABINET

.1 Surface wall mounting, red enamelled steel, identified cabinet with hinged door, shelves with holes for mounting sprinkler heads, a wrench or wrenches suitable for each type of sprinkler head, and a full complement of spare sprinkler heads.

.2 The cabinet is to be sized to accommodate a minimum of four spare heads for each type of head used on the Project, however, each cabinet is to be full of spare heads.

3 EXECUTION

3.01 PIPING INSTALLATION REQUIREMENTS

.1 Provide all required fire protection system piping. Do all piping work in accordance with “Reviewed” shop drawings and NFPA requirements. Unless otherwise specified, piping is to be as follows:

.1 **For underground pipe inside or outside the building**, Class 200, DR14 rigid PVC, braced and secured at bends and tees with concrete blocks in accordance with Municipal standards and details, extended into the building and terminated above the floor or through a wall for connection to the building standpipe system, and wrapped with a rated material such as 3M Fire Barrier Wrap for a minimum two-hour rating.

.2 **For “wet” system piping inside building and above ground**, Schedule 40 grooved end black steel with Victaulic or equal fittings and coupling joints, or, for piping to and including 50 mm (2") diameter, screwed fittings and joints, or piping 65 mm (2½") diameter and larger, welding fittings and welded joints.

.3 **For branch sprinkler piping to heads in suspended ceilings, etc.:** flexible piping installed in accordance with the manufacturer’s instructions.

.4 **For “dry” system piping inside building and above ground**, galvanized Schedule 40 grooved end black steel with Victaulic or equal galvanized fittings and coupling joints, or, for piping to and including 50 mm (2") diameter, galvanized screwed fittings and joints, or piping 65 mm (2½") diameter and larger, galvanized welding fittings and welded joints.

.2 Exceptions to piping requirements specified in paragraph 3 are as follows:

.1 All “wet” zone steel piping, fittings, unions, couplings and flanges for fire protection work exposed to weather either inside or outside the building (including parking garages), are to be galvanized.

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

.3 All pipe sizes, pipe routing, equipment quantities and locations, and layout of work shown on the drawings are to assist you during the tendering period. Ensure adequate fire protection system coverage. Do not reduce the size of the fire protection system main or re-route the main unless approved.

.4 All pipe, fittings, couplings, flanges and similar components are to be cleaned after erection is complete. Any ferrous pipe, fitting, coupling, flange, hanger, support and similar component which exhibits rust is to be wire brush cleaned and carefully coated with suitably coloured primer.

.5 Slope all horizontal piping so that it may be completely drained. Provide capped drain points.

.6 When fire protection work is complete, test the system components and the overall system(s) and submit completed NFPA material and test certificate(s), and any other documentation required.

.7 **Grooved Pipe Coupling Manufacturer's Inspections:** a Manufacturer's factory-trained representative shall periodically visit the job site and visually inspect grooved piping fitting installation for best practices. The installing Contractor shall correct any identified deficiencies. Product that does not meet the visual inspection criteria for proper installation must be corrected and re-examined by the Manufacturer's representative prior to the completion of the project.

3.02 INSTALLATION OF DOUBLE CHECK DETECTOR VALVE ASSEMBLY

.1 Provide a double check valve detector assembly with in the fire protection main inside the building where shown.

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

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

3.03 INSTALLATION OF SHUT-OFF VALVES AND CHECK VALVES

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

.2 Locate all valves for easy operation and maintenance.

.3 Confirm exact locations prior to roughing-in.

3.04 INSTALLATION OF SHUT-OFF VALVE SUPERVISORY SWITCHES

.1 Unless otherwise specified, equip each shut-off valve with a supervisory switch.

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

3.05 INSTALLATION OF FIRE DEPARTMENT CONNECTION(S)

.1 Provide an exterior Fire Department connection(s) where shown. Confirm exact location(s) prior to rough-in. Confirm finish prior to ordering.

.2 Equip each connection with a check valve. Equip each check valve with a ball drip to drain the piping between the Fire Department connection and the check valve, and extend drainage piping from the outlet of the ball drip to the nearest suitable floor drain. Ensure that the drainage piping is properly identified.

3.06 INSTALLATION OF DRY PIPE VALVES

.1 Provide dry pipe valves for fire protection zones where shown.

.2 Connect compressed air piping to each valve, and provide all compressed air piping trim.

.3 When installation is complete, check and test valve operation and adjust as required.

3.07 INSTALLATION OF DRY ZONE AIR COMPRESSOR

.1 Provide an air compressor with air maintenance device and pressure control for the dry pipe zone and dry pipe valve. Secure the compressor to a piping main by means of a mounting bracket supplied with the compressor. Adjust to suit site conditions.

3.08 INSTALLATION OF FLOW ALARM SWITCHES

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

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

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

3.09 INSTALLATION OF ALARM CHECK VALVES

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

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

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

3.10 INSTALLATION OF DRY PIPE VALVES

.1 Provide dry pipe valves for zones where shown.

.2 Connect compressed air piping to each valve, as well as all compressed air piping trim.

.3 When installation is complete, check and test valve operation and adjust as required.

3.11 INSTALLATION OF DRUM DRIPS

.1 Provide drum drips in dry type fire protection zone piping where shown or required. Wherever possible locate drum drips in heated areas. Where drum drips

are located in unheated areas ensure that the trades performing thermal insulation work and electric heating cable pipe tracing work are aware of the number of drum drips required, and the size and location.

3.12 INSTALLATION OF ZONE CONTROL RISER MODULES

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

3.13 INSTALLATION OF SPRINKLER HEADS

.1 Provide all required sprinkler heads. Sprinkler head types are to be in accordance with the following schedule, unless otherwise specified. Sprinkler head manufacturers indicated on the schedule are for type indication purposes. Acceptable manufacturers are listed in Part 2 of this Section.

.2 Unless otherwise specified, sprinkler heads are to be equal to heads specified in the following schedule:

APPLICATION	SPRINKLER HEAD TYPE
Rooms/areas with a suspended ceiling	Victaulic Model V38 Tyco Series RFII "Royal Flush II" concealed pendent Tyco Series TY-FRB recessed pendent Tyco Series TY-FRB pendent with escutcheon plates
Rooms/areas without a suspended ceiling	Victaulic Model V27 Tyco Series TY-RFB pendent
Elevator shafts	Victaulic Model V27 Tyco Series TY-FRB horizontal sidewall
Air handling system outdoor air and relief air plenums (unheated)	Victaulic V36 dry sidewall and upright or VS1 Vic-Flex head for dry locations Tyco Series DS-3 ECOH dry horizontal sidewalls in wet piping Tyco Series TY-FRB upright or horizontal sidewall in dry pipe or anti-freeze piping
Unheated and unfinished areas	Victaulic V36 dry sidewall and upright or VS1 Vic-Flex head for dry locations Tyco Series DS-3 ECOH dry horizontal sidewall in wet piping Tyco Series TY-FRB upright or horizontal sidewall in dry pipe or anti-freeze piping

APPLICATION	SPRINKLER HEAD TYPE
At non-rated windows in rated walls	Tyco Model WS horizontal and pendent vertical sidewall

.3 Sprinkler head locations must be carefully coordinated with all drawings, including architectural reflected ceiling plan drawings, and, where applicable, electrical drawings. Coordinate sprinkler head locations in areas with suspended ceilings with the location of lighting, grilles, diffusers, and similar items recessed in or surface mounted on the ceiling as per the reflected ceiling plans. In areas with lay-in tile, centre the sprinkler head both ways in the lay-in tile wherever possible. Confirm locations prior to roughing-in.

.4 Maintain maximum headroom in areas with no ceilings.

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

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

.7 Do not install sprinklers that have been dropped, damaged, show a visible loss of fluid, or a cracked bulb.

.8 The sprinkler bulb protector shall be removable by hand, without tools or devices that may damage the bulb.

3.14 INSTALLATION OF SPARE SPRINKLER HEAD CABINET

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

3.15 START-UP, TESTING AND COMMISSIONING

.1 **Equipment and System Start-Up:** Refer to requirements of the article entitled Equipment and System Start-Up in the Mechanical Work General Instructions Section, and, all applicable requirements of Authorities having Jurisdiction.

.2 **Commissioning:** Commission equipment after successful start-up and submittal of reports.

.1 Coordinate with fire alarm system testing to commission integrated fire protection and life safety systems as per all requirements of CAN/ULC-S1001 Standard.

.2 Complete testing of automatic sprinkler systems in full compliance with NFPA 13 requirements.

.3 Refer the Mechanical Work Commissioning Section.

.3 **Demonstration and Training:** Refer to the article entitled Equipment and System O & M Demonstration & Training in the Mechanical Work General Instructions Section. Include for four (4) hours of on-site training for two groups of six people.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

.1 **Product Data:** Submit product data sheets for all products specified in this Section.

1.02 QUALITY ASSURANCE

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

.1 National Fire Code of Canada.

.2 NFPA 10, Standard for Portable Fire Extinguishers.

.3 CAN/ULC-S508-02 (including Amendments 1 and 2), Standard for the Rating and Fire Testing of Fire Extinguishers.

2 PRODUCTS

2.01 GENERAL

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

.2 Each extinguisher is to be complete with:

.1 A manufacturer's identification label indicating the extinguisher model number, rating, and operating instructions.

.2 An anodized aluminum or chrome plated forged brass valve with positive squeeze grip on-off operation and a pull-pin safety lock.

.3 Discharge hose with nozzle or horn and hose securing clip.

.4 For wall mounted extinguishers, a wall mounting bracket.

2.02 10B:C RATED CARBON DIOXIDE EXTINGUISHERS

10 B:C carbon dioxide extinguishers are to be 175 mm (6½") diameter, 6.8 kg (15 lb.), each complete with a steel cylinder with a safety red baked enamel finish.

2.03 3A10B:C RATED DRY CHEMICAL EXTINGUISHERS

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

2.04 FIRE EXTINGUISHER CABINETS

.1 **Surface Mounted:** Rectangular break-glass type enclosures sized to suit the extinguishers to be housed, constructed of #18-gauge corrosion resistant steel with a baked white enamel finish, front glass panel, break-glass mechanism, and keyed alike cylinder lock.

.2 **Recessed:** Rectangular cabinets sized to suit the extinguishers to be housed, with a #18-gauge corrosion resistant white enamelled steel tub, #14 gauge cleaned and prime coat painted steel door and adjustable trim assembly with rounded corners, semi-concealed piano hinge, safety glass panel, and flush stainless-steel door latch. Where recessed cabinets are located in fire rated construction the cabinet construction is to maintain the fire rating.

3 EXECUTION

3.01 INSTALLATION OF FIRE EXTINGUISHERS

.1 Provide fire extinguishers of the type(s) specified and as per requirements of NFPA 10.

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

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

.4 You will be responsible for fire extinguishers until after Substantial Performance of the Work.

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

3.02 INSTALLATION OF FIRE EXTINGUISHER CABINETS

.1 Provide wall cabinets for fire extinguishers where shown.

.2 Unless otherwise shown or specified, locate cabinets so that the centreline is approximately 1.2 m (4") above the finished floor.

.3 Confirm exact locations prior to installation.

END OF SECTION

PART 1 - GENERAL

1.1. SUMMARY

1.1.1. The division 22 shall be responsible to carry out all the work set out or referred to in this Section 22 11 16.

1.2. DESCRIPTION OF WORK

1.2.1. Supply, install and commission **Water** Meters, including but not limited to all pipe, by pass valve and two isolation valves for each water meter, all necessary pipe fittings, wiring and interconnects/ fasteners (as required) for the facility as shown in the mechanical drawings required for meeting M&V metering credit requirements.

1.2.2. The **water** meters shall be capable of integrating into the central data logger (i.e., the DMS or BAS).

1.3. SUBMITTALS

1.3.1. Submit dimensioned shop drawings and manufacturer's product data sheets for all metering equipment and associated hardware including but not limited to meter enclosure, encoder and data output modules as applicable for all meters.

1.3.2. Shop drawings must be submitted to the Mechanical Designer, Electrical Designer and M&V Consultant for approval. Any deficiencies in the shop drawings must be resolved in order to achieve the M&V metering strategy requirements.

1.3.3. Do not supply any equipment to this project prior to shop drawing review by the consultant. Shop drawings shall be stamped and signed by the contractor prior to submittal.

1.3.4. After shop drawing review, the approved drawings (i.e., stamped by Electrical and Mechanical designer) will be issued to the General Contractor, Electrical Contractor and Mechanical Contractor for installation.

PART 2 - PRODUCTS

2.1. MATERIALS

2.1.1. Water check meter shall be a compound meter acceptable to local authorities and the DMS supplier.

2.1.2. Water meter size, location and quantities shall be shown on relevant mechanical drawings.

2.1.3. The water meter:

2.1.3.1. Shall be supplied by Division 22 or Division 23 (Mechanical/Plumbing) contractors.

2.1.3.2. Shall be suitable for flow rate, pressure and temperature, and pipe size required for the mechanical/plumbing system operation.

2.1.3.3. Shall be AWWA approved and NSF/ANSI 61 certified, Annex F and Annex G compliant, ± 1.5% accurate ((i.e., a maximum permissible error shall be ± 1.5%

between 0.1 Qmax and Qmax.), but do not need to be sealed for the purposes of M&V.

2.1.3.4. Shall have a visual read-out panel at the field level on the physical water meter.

2.1.3.5. Shall be equipped with suitable pulse head/remote register to provide suitable output signal compatible for integration into the DMS or BAS Network.

PART 3 - EXECUTION

3.1. INSTALLATION

3.1.1. Install water check meter in accordance with manufacturer's instructions and to the satisfaction of the local authority, complete with two isolation valves and a valve by-pass and bleed-off valve/Strainer (if required). All valves, flanges, pipe, joints, fitting and piping material shall meet requirements specified in Section 23 and/or Section 22.

3.1.2. Pre-inspect and measure physical spacing to ensure future safe and easy servicing of water meters.

3.1.3. Ensure that water check meters are to be installed such that normal flow direction matches water meter's corresponding flow direction.

3.1.4. Install water check meter on correct services (per drawings), ensuring they are properly supported with adequate pipe hangers, pipe supports etc., to not put excess strain on supply pipes.

3.1.5. Provide details of physical locations of water check meter in building in DMS As-Built Forms.

3.1.6. Ensure that water meters are accessible with identification tags visible, serial numbers facing outward, for installation inspection purposes by Measurement Canada and DMS Supplier's personnel.

3.1.7. Additional Requirements: Comply with all requirements identified in government regulations.

3.1.8. Data communications cable from water check meters to DMS location shall be provided by Division 23/22/20 (Mechanical/Plumbing) contractors.

3.1.9. If AC or DC power is required for the water, then Division 26 (Electrical) contractor will provide necessary power supply to the water meter location as required in coordination with the Division 22/23 contractors as per water meter manufacture's instruction.

3.1.10. Final connection from the water meter to the DMS shall be completed by Division 16/26 Electrical/DMS contractor as per specifications. All wiring will be done in accordance with Canadian National Electric Code standards and regulations, and in conjunction with the local Electrical Safety Association office.

3.1.11. After installation is complete, test system for leaks and test and adjust controls and safeties. Repair leaks and retest until no leaks occur. Replace any damaged or malfunctioning controls and equipment.

3.1.12. Use laminated plastic (Lamacoid) black-white-black with beveled edges, stainless steel screws, and proper identification engraving for identification nameplates for each water meter and associated valves. Each nameplate to be sized to suit equipment for which it is

provided, and required wording. Confirm nomenclature with Consultant. Various color configurations to be used to differentiate systems. Confirm exact color scheme with Consultant and/or Owner.

3.1.13. Provide necessary patch-up paints on the water pipeline and associated pipe fittings as per code compliance.

3.1.14. Neatly secure exposed communication wire in enclosures and meter ends with approved supports or ties.

3.1.15. Provide conduits (separate conduit for electric power feed wiring and communication data wiring) as sized on drawings for wiring.

3.1.16. Provide necessary wiring (e.g., for power feed, if necessary and data communication) as required through conduits.

3.1.17. Coordinate installation with other trades making connections to equipment, namely control and power connections. Start-up and calibrate equipment as per manufacturer's recommendations.

3.2. CALIBRATION AND MAINTENANCE SERVICE

3.2.1. Include for training as recommended by the manufacturer for safety and operating instructions.

3.2.2. Setup water meters according to manufacturer's instructions.

3.2.3. Commission the water meter by the meter manufacturer representative to the satisfaction of the owner and the Consultant and demonstrate the proper functioning of the metering system. Submit commissioning certificate to the owner.

3.2.4. Provide factory shop test calibration certificates of all water meters from the meter manufacturer.

3.2.5. Provide records of on-site point-to-point calibration of meters confirming that correct multipliers were used while programming the meter data on the central data logger i.e., the DMS to read and archive accurate water meter data.

3.2.6. Division 23/22 Contractor will coordinate with Division 26 to demonstrate and confirm that the all meter data physically recorded on the meter itself are the same readings integrated, trend-logged and archived on the DMS with proper time stamp, unit of measurement, correct meter ID, 15-minute's interval and archived on the historical database for at least 36-months.

3.2.7. All equipment shall be free from defect in materials and workmanship under normal use and service for the period of twelve (12) months from the date of substantial completion.

3.2.8. All equipment will be verified by a factory trained technician approved by the water meter manufacturer.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Do the work in accordance with current Ontario Building Code, and local authorities/municipalities having jurisdiction.

1.2 Product Data

.1 Submit shop drawings for valves.

.2 Provide maintenance data for incorporation into project documentation.

PART 2 - PRODUCTS

2.1 Piping

.1 Domestic hot and cold water piping, within building, above ground and buried.

.1 Copper tube, hard drawn, above ground, type 'L' to ASTM B88-83.

.2 Copper tube, annealed soft, buried, type 'K' to ASTM B88-83.

2.2 Fittings

.1 Brass or bronze flanges and flanged fittings: to ANSI B16.24.

.2 Brass or bronze threaded fittings: to ANSI B16.15.

.3 Solder joints, cast bronze: lead free.

.4 Rubber gaskets, 1.6mm thick: to ANSI A21.11, AWWA C111-80.

.5 Bolts, nuts, hex head and washers: to ASTM A307-86a, heavy series.

.6 Solder, Silvabrite 100, lead free antimony free silver bearing.

2.3 Ball Valves

.1 NPS 2 and under, soldered:

.1 To MSS SP-80, Class 150, 1 MPa, bronze body, chrome ball, PTFE Teflon adjustable packing, brass gland and PTFE Teflon seat, steel lever handle.

.2 Standard of Acceptance: Crane 9322; Jenkins 902J; Kitz 59; Toyo 5049A; Apollo 70-200; Mas B-4.

.2 NPS 2 and under, screwed:

.1 To MSS SP-80, Class 150, 1 MPa, bronze body, chrome ball, PTFE Teflon adjustable packing, brass gland and PTFE Teflon seat, lever handle with NPT to copper adaptors.

.2 Standard of Acceptance: Crane 9302; Jenkins 901J; Kitz 58, Toyo 5044; Apollo 70-100; Mas B-3.

2.4 Check Valves

.1 NPS 2 and under, soldered:

.1 To MSS SP-80, class 125, 860 kPa, bronze body, bronze swing disc, screw in cap, regrindable seat.

.2 Standard of Acceptance: Crane 1342; Jenkins 4093J; Kitz 23; Toyo 237.

.2 NPS 2 and under, screwed:

.1 To MSS SP-80, class 125, 860 kPa, bronze body, bronze swing disc, screw in cap, regrindable seat.

.2 Standard of Acceptance: Crane 37; Jenkins 4092J; Kitz 22; Toyo 236.

.3 NPS 2-1/2 and over:

.1 Class 125, 860 kPa, iron body, bronze mounted, swing check flanged.

.2 Standard of Acceptance: Crane 373; Jenkins 587J; Kitz 78; Toyo 435.

PART 3 - EXECUTION

3.1 Installation

.1 Make connections to fixtures and equipment in accordance with manufacturers instructions.

.2 Install tubing close to building structure to minimize furring, conserve headroom and space. Group exposed piping and run parallel to walls.

.3 Cut square, ream and clean tubing and tube ends, clean recesses of fittings and assemble without binding.

.4 Lay buried tubing in compacted sand, free of clay, snow, ice and organic material.

.5 Isolate equipment and branches with valves.

.6 Provide necessary chemicals and equipment and disinfect system to requirements of authority having jurisdiction.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Piping work in accordance with current Ontario Building Code.

PART 2 - PRODUCTS

2.1 Plastic Piping and Fittings

.1 For buried sanitary, storm and vent piping inside building and buried sanitary and storm outside building to:

.1 CAN 3 B181.1-M85 for ABS DWV,

.2 CAN/CSA B181.2-M87 for PVC DWV, or

.3 CAN/CSA B182.1-M87 for Plastic DWV.

.2 Joints:

.1 Solvent weld for PVC: to ASTM D2564-84.

.2 Solvent weld for ABS: to ASTM D2235-81.

2.2 Copper Pipe and Fittings

.1 For above ground sanitary & vent piping, drain piping from ventilation ducts, equipment and plenums, Type DWV to:

.1 ASTM B306-83.1 for copper tube.

.2 CSA B158.1-1976 for cast brass fittings.

.3 ANSI B16.29-1980 for wrought copper fittings.

.4 Solder: lead free.

2.3 Cast Iron Piping and Fittings

.1 Buried sanitary, storm and vent, minimum NPS 3 to CAN 3-B70-M86 with one layer of protective coating.

.1 Joints

.1 Mechanical Joints

.1 Neoprene or butyl rubber compression gaskets: to ASTM C564-70 (1982) or CAN 3-B70-M86.

.2 Stainless steel clamps.

.2 Hub and Spigot

.1 Caulking lead: to CSA B67-1972.

.2 Cold caulking compounds.

.2 Above ground sanitary, storm and vent, to CAN 3-B70-M86 with one layer of protective coating.

.1 Joints

.1 Hub and Spigot

.1 Caulking lead to CSA B67-1972.

.2 Mechanical Joints

.1 Neoprene or butyl rubber compression gaskets with stainless steel clamps.

.3 Cast iron couplings

.1 Complete with neoprene gaskets and stainless steel bolts and nuts.

PART 3 - EXECUTION

3.1 Installation

.1 Install buried pipe on 150mm bed of clean sand, shaped to accommodate hubs, to line and grade as indicated. Backfill with clean sand.

.2 Install piping parallel and close to walls and ceilings to conserve headroom and space, and to grade indicated.

.3 Provide drain piping, to terminate above the nearest service sink, hub or funnel floor drain, from the following:

.1 Intake ventilation ducts.

.2 All mechanical equipment drain points, where required and indicated on shop drawings.

.3 Energy Recovery unit drain points.

.4 Plenum drains.

.5 Heat pump condensate drains.

.6 Automatic/manual air vents in piping systems.

.5 Minimum size of buried drains shall be 75mm (3").

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

.1 **Product Data**: Submit product data sheets for all products specified in this Section.

1.02 QUALITY ASSURANCE

.1 All electric hot water heaters are to be certified to CAN/CSA-C191, Performance of Electric Storage Tank Water Heaters for Domestic Hot Water Service.

2 PRODUCTS

2.01 ELECTRIC HOT WATER HEATER

.1 CSA certified electric hot water heater with model number and performance as specified on the drawings, and complete with:

.1 A 1035 kPa (150 psi) rated (working pressure) steel tank, glass lined, insulated (except for control panel area) with injected minimum R-16 foam insulation, covered with an enamelled steel jacket, and equipped with 40 mm (1½") diameter NPS brass nipple water inlet and outlet connections, a drain valve, and sacrificial anode rods.

.2 Removable multiple immersion heating elements, each consisting of a wire filament in a sealed stainless-steel sheath.

.3 An ASME rated temperature and pressure relief valve.

.4 A factory prewired power and control panel.

.2 The enamelled steel ventilated control panel is to be equipped with removable glass fibre insulation to cover the bare area of the tank, a hinged door, multiple knockouts, a ground screw, and the following:

.1 A terminal block for power wiring connections.

.2 Magnetic contactors for heating elements.

.3 An adjustable immersion thermostat.

.4 Manual reset immersed high temperature limit control for each element.

.5 Fuse block with fuses.

.6 An element diagnostic panel with LED’s for each element to monitor the on-off operation of each element.

.7 An aluminium drain/drip pan 50 mm (2”) diameter wider than the heater base and complete with 50 mm (2”) high rolled edges and a 25 mm (1”) diameter drain connection spigot with PVC fitting.

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

.3 Acceptable manufacturers are:

.1 Rheem Canada Ltd.

.2 John Wood (GWS Water Heating Co.)

.3 A.O. Smith Water Products Co.

.4 Bradford White Canada Inc.

2.02 INDIRECT DOMESTIC HOT WATER STORAGE TANK

.1 Vertical steel domestic hot water storage tank, 1103 kPa (150 psi) rated, sized in accordance with the drawing schedule, constructed in accordance with the ASME Boiler Pressure Vessel Code, Section IV, Part HLW, and complete with:

.1 A double interior coating of high temperature porcelain enamel, two magnesium anodes rigidly secured in place, 50 mm (2") thick polyurethane foam insulation, and an enamelled steel jacket.

.2 Tank openings for circulating lines, hot water outlet relief valve, temperature control drain valve and a thermometer.

.3 A ASME rated relief valve.

.4 A drain valve.

.5 An aquastat for pump/heater control.

.6 High output, low pressure drop, corrugated stainless 316L heat exchanger

.2 Acceptable manufacturers are:

.1 Viessman

.2 HTP

.3 A.O. Smith Water Products Co.

.4 Bradford White Canada Inc.

3 EXECUTION

3.01 INSTALLATION OF ELECTRIC HOT WATER HEATER

.1 Provide an electric domestic hot water heater where shown.

.2 Secure the heater in place, level and plumb, in a drip pan on a concrete housekeeping pad and:

.1 Pipe the temperature/pressure relief valve outlet to drain.

.2 Pipe the drip pan to drain.

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

.3 Set the thermostat to produce 60° C (140° F) hot water.

.4 **Manufacturer's Certification:** Submit a copy of the letter prior to Substantial Performance.

.5 **Commissioning:** Commission equipment after successful start-up and submittal of reports. Refer the Mechanical Work Commissioning Section.

.6 **Demonstration and Training:** Include for two hours of on-site training for two groups of six people.

3.02 INSTALLATION OF DOMESTIC HOT WATER STORAGE TANKS

.1 Provide domestic hot water storage tanks where shown.

.2 Secure each tank in place, level and plumb on a reinforced concrete housekeeping pad by means of machine bolts.

.3 Install piping manifolds for the tanks.

.4 Unless otherwise specified or instructed, set the tank control to maintain design hot water temperature Check all control and safeties and adjust as required.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Do the work in accordance with current Ontario Building Code.

1.2 Shop Drawings

.1 Submit shop drawings in accordance with Mechanical General Provisions 21 05 01.

PART 2 - PRODUCTS

2.1 Floor Drains

.1 Type FD-1 (Washrooms): Duco coated cast iron body with reversible clamp device and adjustable 127mm (5") extra heavy nickel bronze 12mm (1/2") heavy duty 'HD' thick strainer secured with S.S. screws, 100mm (4") throat on strainer. In quarry or mosaic tiled areas, provide square 'B' 127mm x 127mm (5" x 5") extra heavy polished bronze strainer.

.1 Standard of Acceptance: Smith #2010AHD.

.2 Type FD-2 (Unfinished Areas, Storage Rooms, etc): Dunco coated cast iron body with seepage flange, adjustable collar, clamping device and 200mm (8") diameter grate.

.1 Standard of Acceptance: Smith #2320.

.3 Type FD-3, Funnel type (Mechanical Rooms): Duco coated cast iron body with seepage flange, adjustable collar, clamping device and 200mm (8") with full opening in grate for 100mm x 225 mm (4" x 9") oval funnel.

.1 Standard of Acceptance: Smith #2320/3591.

.4 Type FD-4, Wood Floor Drain: epoxy coated cast iron body, 5" (127 mm) diameter nickel bronze, heel-proof round grate, extension, steel securing flange with countersunk holes no hub outlet.

.1 Standard of Acceptance: Watts #FD-380-6-E

2.2 Roof Drains

.1 All duco coated 380mm (15") dia. cast iron body with under deck clamp, adjustable extension and sump receiver, 280mm (11") secured aluminum dome, and 150mm (6") high flow control weir.

.2 Standard of Acceptance: Smith 1083 ERCAD. (Controlled Flow Type)
Standard of Acceptance: Smith 1083 ERCID. (Standard Flow Type)

2.3 Area Drains

.1 Type AD-1 (Lightwell): Epoxy coated cast iron body, reversible flashing clamp with primary and secondary weepholes, trap primer connection with plug, no hub outlet Watts -K 5" (127 mm) diameter, nickel bronze, dome strainer.

.1 Standard of Acceptance: Watts #FD-100-C-K-7

.2 Type AD-2 (Preschool Outdoor Play) 10-5/8" [270mm] Square top prom-deck drain,Dura-Coated cast iron body with rotatable square promenade frame with seepage slots, frame clamps, stainless steel perforated extension and decorative light duty heel and vandal proof secured grate with 3/16" [5mm] wide slots and nickel bronze veneer frame and grate.

.1 Standard of Acceptance: ZURN ZN158-DT-VP-85

2.4 Cleanouts

.1 Line cleanouts (cast iron pipe): Taper thread cover secured to body with full size pipe opening.

.1 Standard of Acceptance: Smith #4420.

.2 Urinal Cleanout: with stainless steel bolt and wing nut complete with round polished SS access cover and secured with vandal proof screws.

.1 Standard of Acceptance: Smith #4472-Mod-U.

.3 Floor Cleanouts:

.1 Unfinished areas and outside areas: Duco coated cast body with integral clamp device and removable positive seal cleanout plug and heavy duty 150mm (6”) scoriated safety finish, adjustable cover secured with S.S. screws.

.1 Standard of Acceptance: Smith Series 4220.

.2 Linoleum and Tiled areas; similar to above with square nickel bronze cover and frame recessed for tile.

.1 Standard of Acceptance: Smith Series 4140.

.3 Terrazzo areas: Similar to above, with frame recessed for Terrazzo.

.1 Standard of Acceptance: Smith Series 4180.

.4 Other finished areas: Similar to above with NB frame and cover.

.1 Standard of Acceptance: Smith Series 4100; for heavy duty areas, use Smith Series 4100HD.

2.5 Water Hammer Arrestors

.1 Pre-charged stainless steel bellows in a stainless steel casing, size according to manufacturer's recommendations.

.2 Standard of Acceptance: Smith Series HA/P.P.P. Series SC.

2.6 Trap Seal Primers

.1 Provide for all floor drains automatic trap primer complete with sediment strainer, union and access door for concealed installation.

.2 Provide NPS 1/2 Type 'K' hard copper tubing connection between trap primer valve and floor drain.

.3 Trap seal primers serving individual or remote area drains with integral back flow preventer and vacuum breaker.

.4 Standard of Acceptance: P.P.P. # PO-500.

2.7 Strainers

.1 860 kPa gauge pressure 'Y' type strainer with 20 mesh, monel, bronze or stainless steel removable screen.

.2 50mm nominal and under, bronze and screwed with brass cap.

.1 Standard of Acceptance: STM. Specialist Colton 300Y TB, Sarco BT; Armstrong F4SC, Crane 988-1/2.

2.8 Non-Freeze Wall Hydrants, WH - Exterior

.1 Concealed type key operated non-freeze wall hydrant with S.S. box, 180^{o} cover, door and hydrant face, all bronze head 1/4 turn non-drip ceramic cartridge, galvanized casing and adjustable wall flange.

.2 Standard of Acceptance: Smith 5509QT.

2.9 Backflow Preventer - Reduced Pressure

.1 Reduce pressure zone type, all bronze construction with stainless steel internal parts, complete with strainer, test cocks, and shut-off valves.

.2 Size: 3/4".

.3 For use in make-up water connections.

.4 Standard of Acceptance: Watts 009 series.

2.10 Domestic Water Expansion Tanks

.1 **Tanks:** Lead free, fixed or replaceable bladder type steel tank in-line or stand type as indicated, certified to NSF/ANSI Standard 61, factory pressurized (adjustable) with permanent separation of air and water, suitable for a maximum working pressure of 1035 kPa (150 psi) at 115° C (240° F), constructed and stamped in accordance with the ASME Code Section VIII for Unfired Pressure Vessels and complete with a red oxide primer finish and the following:

.1 A NPT stainless steel system connection.

.2 A Schrader air charging valve.

.3 A heavy-duty butyl rubber bladder.

.4 A polypropylene liner.

.5 A tapping for installation of a pressure gauge.

.6 A tapping for a drain valve.

.7 For horizontal tanks only, enamelled steel mounting saddles supplied loose.

.2 Tanks for domestic cold-water booster pump sets are to be sized for the minimum run time of the pump set.

.3 **Acceptable Manufacturers:** Acceptable manufacturers are:

.1 Watts Canada

.2 Amtrol Inc. “THERM-X-TROL”

.3 Xylem Inc. “Bell & Gossett”

.4 Taco Inc.

.5 Calefactio Solutions Inc. “Expandflex”

.6 Wessels Co.

PART 3 - EXECUTION

3.1 Cleanouts

.1 In addition to those required by code, install at base of all soil and waste stacks, and rainwater leaders and where indicated.

.2 Bring cleanouts to wall or finished floor unless serviceable from below floor. Use Y bend and 1/8 turn to bring cleanout to floor.

.3 Building drain cleanout and stack base cleanouts: line size to maximum NPS 4.

.4 Install cleanouts at ends of each drainage line and at all changes of direction of 45 deg. or more.

3.2 Water Hammer Arrestors

.1 Install on branch supplies to each fixture or group of fixtures. Provide isolation valves for each arrestor and insure each arrestor is accessible for service.

3.3 Trap Seal Primers

.1 Install on cold water supply to nearest plumbing fixture, in concealed space.

3.4 Strainers

.1 Install in accordance with manufacturer's instructions. Allow sufficient room to remove basket.

3.5 Backflow Preventers

.1 Supply with Watts series AG air gaps and pipe to drain.

3.6 Installation Of Domestic Water Expansion Tanks

.1 Provide domestic water expansion tanks where shown.

.2 Secure the vertical tank stand to a concrete housekeeping pad by means of machine bolts.

.3 Connect each tank with valved piping as indicated. Check the tank air charge and adjust to suit the system.

.4 Provide a pressure gauge with cock to indicate system pressure. Provide a drain valve. Pressure gauges and drain valves are to be as per the mechanical work Section entitled Basic Materials and Methods.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Do the work in accordance with Ontario Building Code, latest edition and to the requirements of authorities having jurisdiction.

1.2 Shop Drawings

.1 Submit shop drawings in accordance with Mechanical General Provisions 15010.

.1 Indicate: dimensions and construction details.

1.3 Maintenance Data

.1 Provide maintenance data for incorporation into maintenance manual specified in Mechanical General Provisions 21 05 01.

.2 Data to include:

.1 Description of equipment giving manufacturers name, type, model year, capacity and serial numbers.

.2 Details of operation, servicing and maintenance.

.3 Recommended spare parts list.

1.4 Fixtures and Trim

.1 Architectural drawings to govern in determination of number and location of fixtures.

.2 Fixtures to be product of one manufacturer and of same type.

.3 Trim to be product of one manufacturer and of same type.

PART 2 - PRODUCTS

2.1 Water Closets

.1 WC-1 (Infant)

.1 Floor mounted tank, low consumption, vitreous china elongated syphon action jetted bowl and bolted lined tank complete, 4.8L (1.28 Gal.) flush with large cast rib for china to china tank assembly and splash block, concealed trapway and with flange bolts, bolt caps, floor flange and gasket, C.P. rigid polished horizontal with angle stop, escutcheon and flexible riser, baby heavy duty solid plastic open front seat less cover, with

check hinges and chromated steel posts, washers and nuts. Supply kit with lead-free chrome plated brass supply stops with full-turn brass stem, no plastic and chrome plated risers, UPC low-lead certified.

.2 Standard of Acceptance:

Bowl: American Standard “Baby Devoro” #2315.228.020
Supply: McGuire #LFH166LKN3
Seat: Centoco #AM2300STCC.001

.2 WC-2 (Toddler & Pre-School)

1. Provide Standard Height (maximum height 386mm [15-1/8”]), round front, 3.8 LPF Single-Flush, two-piece Toilet, high glazed vitreous china surface. ASME A112.19.2 and CSA B45 compliant, minimum MaP rating 800g. Extra heavy-duty, open front with cover for round bowl with stainless steel hinge. Supply kit with lead-free chrome plated brass supply stops with full-turn brass stem, no plastic and chrome plated risers, UPC low-lead certified.

2. Standard of Acceptance:

Bowl: Winfield TB32420
Tank: Winfield TK32420
Supply: McGuire #LFH17BV
Seat: Centoco #460STS

.3 WC-3 (Adult, Wheelchair use)

1. Provide Comfort Height (maximum 17”), Elongated Front, 3.0 / 1.9 LPF Dual-Flush, Two-piece Toilet, high glazed vitreous china surface. ASME A112.19.2 and CSA B45 compliant, minimum MaP rating 800g. Extra heavy-duty, open front with cover for elongated bowl with stainless steel hinge. Supply kit with lead-free chrome plated brass supply stops with full-turn brass stem, no plastic and chrome plated risers, UPC low-lead certified.

2. Standard of Acceptance:

Bowl: Proficiency Standard Height N7717 DF
Supply McGuire #LFH17BV
Seat Centoco # 820STSS

2.2 Lavatories

.1 L-1 (Infant, Toddler & Pre-School,)

.1 Wall hung, 508mm x 457mm x 127mm (20” x 18” x 5”), vitreous china, splash back, front overflow, self-draining deck, for concealed arm support, trim fittings, C.P. 102mm (4”) centers, C.C. deck-mounted, solid cast brass lead-free body, Electronic no touch faucet 1.35 LPM (0.35 GPM), flow aerator outlet (aerator to be removable and replaceable), C.P. open grid, ‘P’ trap, C.P. polished, cast brass 32mm (1-1/4”) with cleanout and

escutcheon, C.P. polished, rigid horizontal with V.P. loose key angle stop, escutcheon and flexible riser, heavy-duty carrier with steel pipe legs, block base feet support and extended concealed arms. Provide hot & cold water to faucet.

.2 Standard of Acceptance:

Basin: American Standard “Penlyn” #0373.027.020
Faucet: Sloan Lino # EAF-200-LT w/ ETF-312-A
Box Mounted Hardwired Transformer: Sloan #EAF-37
Thermostatic Mixing Valve: Sloan #BDT
Strainer: McGuire #155A
Supplies: McGuire #LFH165LKN3
Trap: McGuire #8872C
Carrier: Watts #CA-421
Trap Cover: McGuire PROWRAP #PW2000

.2 L-2 (Adult, Wheelchair use)

.1 3 holes, 4" (102 mm) center, 457 mm x 403 mm x 175 mm (18" x 15-7/8" x 6-7/8") high, Vitreous china, White Finish, for carrier with steel plate, Front overflow, faucet ledge, back splash, wall hanger. Electronic 'No-Touch' Hard Wired powered Faucet**,** Chrome plated finish, Center hole only, cast body, 1.35 LPM (0.35 GPM) aerator spray outlet (aerator to be removable and replaceable), 148 mm (5-13/16") projection reach, dual infrared sensor with automatic setting feature and automatic self-adapting technology, concealed above deck magnetic solenoid valve, microprocessor based logic, 120 VAC / 6 VDC. Box Mount Hardwired Transformer**,** 120 VAC/ 6 VDC. Thermostatic mixing valve**,** solid bimetal (bronze, brass, stainless steel), Hot limit stop set to a maximum of 43 °C (109.4 °F). Screwdriver adjustment temperature dial with scale: COLD-HOT. Provide tee, adaptors and flex. copper tubing to suit installation. Open Grid Drain**,** cast brass one-piece top, 17 GA. (1.5 mm) tubular 32 mm (1-1/4") tailpiece. Faucet Supplies, 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. P-Trap, heavy cast brass adjustable body, with slip nut, 32 mm (1-1/4") size, Shallow wall flange and seamless tubular wall bend. Fixture Carrier, universal steel hangar support plates with integral mounting brackets, heavy gauge epoxy coated steel uprights with welded feet. For one unit: 102 mm (4") for two to six units in a row: 152 mm (6") finished metal stud wall to back of pipe space.

.2 Standard of Acceptance:

Basin: American Standard Murro with EverClean
#0955.001EC/0062.000EC Basin
Faucet: Sloan Lino #EAF-200-LT
Box Mounted Hard wired Transformer: Sloan #EAF-37
Thermostatic Mixing Valve: Sloan #BDT
Strainer: McGuire #155A

Supplies: McGuire #LFH165LKN3
Trap: McGuire #8872C
Trap Cover: American Standard 0062.000EC.020
Carrier: Watts #CA-421
Carrier (Back-to-Back): Watts #CA-421-D

2.3 Mop Service Basins

.1 JS-1

.1 Precast terrazzo mop basin 914mm x 610mm x 305mm (36" x 24" x 12") deep, floor mounted with one piece stainless steel cap on all sides and integral drain with strainer, trim fitting faucet, C.P. 203mm (8”) C.C. wall mounted, cast brass body, lead free, 1/4 turn ceramic disc cartridges, with cast metal lever handles, hose end vacuum breaker, integral stops, 787mm (31”) vinyl hose and hanger, SS back with 2 panels, ‘P’ trap 75mm (3”).

.2 Standard of Acceptance:

Basin: Stern Williams #SB-300-BP
Fittings: Chicago #897-CCP
Hose & wall hook: Stern Williams #T-35
Mop Hanger: Stern Williams #T-40
Back Splash panel: Stern Williams #BP

2.4 Sinks

.1 S (WC & Change Rooms)

.1 Sink & faucet supplied by another division. Point of use thermostatic water mixing valve, nickel plated bronze body, temperature adjusting spindle, 10 mm (3/8") inlets and outlet FNPT connections, Integral checks, offer temperature range between 35 °C (95 °F) and 46 °C (114.8 °F). Set valve temperature at 40 °C (104°F). Provide tee, adaptors and flex. copper tubing to suit installation. Provide tempered water to hot side of faucet. Faucet Supplies, 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. Provide P-Trap, same material as the connecting pipe drain.

2 Standard of Acceptance:

Mixing Valve: Lawler #570-86820
Supplies: McGuire #LFH165LKN3

.2 S-1 (Toddler, Infant, Preschool)

.1 Single Bowl, 1 hole, 410 mm (16-1/8") wide x 522 mm (20-9/16") long x 203 mm (8") high deep, Counter mounted, backledge, Grade 18-10 18 GA. (1.2 mm) 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" (89 mm) crumb cup waste assembly with 1-1/2" (38 mm) tailpiece. Single handle Faucet**,** Polished chrome finish, center hole only, brass body, washerless ceramic disc valve cartridges, 3.8LPM (1.0 GPM) aerator outlet (aerator to be removable and replaceable), brass swing spout, 170 mm (6-11/16") projection reach, Lever handle, pull-out spray with adjustable spray pattern**.** Point Of Use Thermostatic Water Mixing Valve, nickel plated bronze body, temperature adjusting spindle, 10 mm (3/8") inlets and outlet FNPT connections, Integral checks, offer temperature range between 35 °C (95 °F) and 46 °C (114.8 °F). Set valve temperature at 40 °C (104°F). Provide tee, adaptors and flex. copper tubing to suit installation. Provide tempered water to hot side of faucet**.** Faucet Supplies, 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. P-Trap**,** heavy cast brass adjustable body, with slip nut, 38 mm (1-1/2") size, Box flange and Seamless tubular wall bend.

.2 Standard of Acceptance:

Bowl:	Franke Commercial #LBS6408P-1/1
Faucet:	American Standard Pekoe # 4332.310.002
Mixing Valve:	Lawler #570-86820
Trap:	McGuire #8912CB
Supplies:	McGuire #LFH165LKN3

.3 S-2 (Toddler, Infant, Preschool)

.1 Double Bowl, 1 hole, 794 mm (31-1/4") wide x 522 mm (20-9/16") long x 254 mm (10") high deep, Counter mounted, back-ledge, Grade 18-10 18 GA. (1.2 mm) 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" (89 mm) crumb cup waste assembly with 1-1/2" (38 mm) tailpiece. Single handle Faucet, Polished Chrome finish, Center hole only, Brass body, washerless ceramic disc valve cartridges, 3.8LPM (1.0 GPM) aerator outlet (aerator to be removable and replaceable), Brass swing spout, 170 mm (6-11/16") projection reach, Lever handle, Pull-out spray with adjustable spray pattern. Thermostatic Water Mixing Valve, nickel plated bronze body, temperature adjusting spindle, 10 mm (3/8") inlets and outlet FNPT connections, Integral checks, offer temperature range between 35 °C (95 °F) and 46 °C (114.8 °F). Set valve temperature at 40 °C (104°F). Provide tee, adaptors and flex. copper tubing to suit installation. Provide tempered water to hot side of faucet. Faucet Supplies, 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. P-Trap, heavy cast brass adjustable body, with slip nut, 38 mm (1-1/2") size, Box flange and Seamless tubular wall bend.

.2 Standard of Acceptance:

Bowl: Franke Commercial #LBD6410PCB-1/1
Faucet: American Standard Pekoe #4332.310.002
Mixing valve: Lawler #570-86820
Trap: McGuire #8912CB P-Trap
Supplies: McGuire #LFH165LKN3

.4 S-3 (Laundry)

.1 Single Bowl Countertop Mount Sink**,** 1 hole, 511 mm (20-1/8") wide x 522 mm (20-9/16") long x 254 mm (10") high deep, Counter mounted, backledge, grade 18-8, 20 GA. (0.9 mm) stainless steel, bright mirror finish rim, satin finish bowls, radius coved bowls corners, Mounting kit provided, Fully undercoated to reduce condensation and resonance, 89 mm (3-1/2") crumb cup waste assembly with 38 mm (1-1/2") tailpiece.
Single handle Faucet**,** Polished Chrome finish, Center hole only, Brass body, washerless ceramic disc valve cartridges, 5.7LPM (1.5 GPM) aerator outlet (aerator to be removable and replaceable), Brass swing spout, 170 mm (6-11/16") projection reach, Lever handle, Pull-out spray with adjustable spray pattern. Faucet Supplies**,** 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 P-Trap**,** heavy cast brass adjustable body, with slip nut, 38 mm (1-1/2") size, Box flange and Seamless tubular wall bend.

.2 Standard of Acceptance:
Bowl: Kindred #QSL2020/10/1
Faucet: American Standard Pekoe #4332.310.002
Supplies**:** McGuire #LFH165LKN3
Trap: McGuire #8912CB P-Trap

.5 S-4 (Servery)

.1 Triple bowl Under counter sink, 1067 mm (42") wide x 451 mm (17-3/4") long x 203 mm (8") high deep, Counter mounted, no ledge, Grade 18-8 20 GA. (0.9 mm) type 302 stainless steel, silk finished rim, radiant silk finished bowls, radius coved bowls corners, Mounting kit provided, Fully undercoated to reduce condensation and resonance, 89 mm (3-1/2") crumb cup waste assembly with 38 mm (1-1/2") tailpiece. Single handle Faucet, Polished Chrome finish, Center hole only, Brass body, washerless ceramic disc valve cartridges, 5.7LPM (1.5 GPM) aerator outlet (aerator to be removable and replaceable), Brass swing spout, 170 mm (6-11/16") projection reach, Lever handle, Pull-out spray with adjustable spray pattern. Point Of Use Thermostatic Water Mixing Valve, nickel plated bronze body, temperature adjusting spindle, 10 mm (3/8") inlets and outlet FNPT connections, Integral checks, offer temperature range between 35 °C (95 °F) and 46 °C (114.8 °F). Set valve temperature at 40 °C (104°F). Provide tee, adaptors and flex. copper tubing to suit installation. Provide tempered water to hot side of faucet. Faucet Supplies, 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**.** P-Trap, heavy cast brass adjustable body, with slip nut, 51 mm (2") size, shallow wall flange and seamless tubular wall bend.

.2 Standard of Acceptance:

Bowl: Kindred #QTU1842/8
Faucet: American Standard Pekoe #4332.310.002
Mixing Valve: Lawler #570-86820
Supplies**:** McGuire #LFH165LKN3
Trap: McGuire #8904C P-Trap

.6 S-5 (Toddler, Infant, Preschool – Counter Mounted Above Counter Basin)

.1 American Standard Morning, Center hole only, Round shape, Vitreous china, White Finish, Above counter, Front overflow, integral faucet ledge. Provide basin rim sealant. Electronic 'No-Touch' Hard Wired powered Faucet, Chrome plated finish, Center hole only, cast body, 1.3 LPM (0.35 GPM) aerator spray outlet (aerator to be removable and replaceable), 148 mm (5-13/16") projection reach, dual infrared sensor with automatic setting feature and automatic self-adapting technology, concealed above deck magnetic solenoid valve, microprocessor based logic, 120 VAC / 6 VDC. Box Mount Hardwired Transformer, 120 VAC/ 6 VDC. Thermostatic mixing valve, solid bimetal (bronze, brass, stainless steel), Hot limit stop set to a maximum of 43 °C (109.4 °F). Screwdriver adjustment temperature dial with scale: COLD-HOT. Provide tee, adaptors and flex. copper tubing to suit installation. Open Grid Drain, cast brass one piece top, 17 GA. (1.5 mm) tubular 32 mm (1-1/4") tailpiece. Faucet Supplies, Chrome plated finish polished brass, commercial duty 1/4 turn ball valve angle stops, 13 mm (1/2") I.D. Inlet x 127 mm (5") horizontal extension tubes, convertible 1/4 turn/loose key handles, Escutcheon and flexible copper risers. P-Trap, heavy cast brass adjustable body, with slip nut, 32 mm (1-1/4") size, shallow wall flange and seamless tubular wall bend.

.2 Standard of Acceptance:

Bowl: American Standard Morning #0670.312.020
Faucet: Sloan Lino #EAF-200-LT
Box Mounted Hard wired Transformer: Sloan #EAF-37
Mixing Valve: Sloan #BDT
Drain: McGuire #155A Open Grid Drain
Trap: McGuire #8872C P-Trap
Supplies: McGuire #LFH170BV

.7 S-6 (Servery & Staff)

.1 Single Bowl Under counter sink, 370 mm (14-9/16") wide x 429 mm (16-7/8") long x 203 mm (8") high deep, Counter mounted, no ledge, Grade 18-10 18 GA. (1.2 mm) type 304 stainless steel, silk finished rim, radiant silk finished bowls, radius coved bowls corners, Mounting kit provided,

Fully undercoated to reduce condensation and resonance, 89 mm (3-1/2") crumb cup waste assembly with 38 mm (1-1/2") tailpiece
Single handle Faucet**,** Polished chrome finish, center hole only, brass body, washerless ceramic disc valve cartridges, 3.8LPM (1.0 GPM) aerator outlet (aerator to be removable and replaceable), brass swing spout, 170 mm (6-11/16") projection reach, Lever handle, pull-out spray with adjustable spray pattern**.** Point Of Use Thermostatic Water Mixing Valve, nickel plated bronze body, temperature adjusting spindle, 10 mm (3/8") inlets and outlet FNPT connections, Integral checks, offer temperature range between 35 °C (95 °F) and 46 °C (114.8 °F). Set valve temperature at 40 °C (104°F). Provide tee, adaptors and flex. copper tubing to suit installation. Provide tempered water to hot side of faucet**.** Faucet Supplies, 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. P-Trap**,** heavy cast brass adjustable body, with slip nut, 38 mm (1-1/2") size, Box flange and Seamless tubular wall bend.

.2 Standard of Acceptance:

Bowl:	Franke Commercial #KBX110-13
Faucet:	American Standard Pekoe # 4332.310.002
Mixing Valve:	Lawler #570-86820
Trap:	McGuire #8912CB
Supplies:	McGuire #LFH165LKN3

.8 S-7 (Janitors/Custodian Wall Hung Basin-Two Handle Faucet c/w EW-2)

.1 Commercial hand wash sink without overflow, custom, 470 mm x 483 mm x 273 mm (18-1/2" x 19" x 10-3/4") high, Grade 18-8 20 GA. (0.9 mm) type 302 stainless steel, polished satin finish rim, for carrier with steel plate, faucet ledge, 95 mm (3-3/4") high backsplash, wall hanger. ~~Custom punched basin is non-refundable.~~ Two handles Faucet, chrome plated finish, Center hole only, ECAST construction lead free (equal or less than 0.25%) Solid brass construction, 1/4 turn ceramic disc valve cartridges, 5.7 LPM (1.5 GPM) pressure compensating 5.7LPM (1.5 GPM) aerator outlet (aerator to be removable and replaceable), 133 mm (5-1/4") projection rigid/swing gooseneck spout, 102 mm (4") metal vandal proof wrist blade handles with blue and red index buttons. Point Of Use Thermostatic Water Mixing Valve, nickel plated bronze body, temperature adjusting spindle, 10 mm (3/8") inlets and outlet FNPT connections, Integral checks, offer temperature range between 35 °C (95 °F) and 46 °C (114.8 °F). Set valve temperature at 40 °C (104°F). Provide tee, adaptors and flex. copper tubing to suit installation. Provide tempered water to hot side of faucet. Open Grid Drain, cast brass one piece top, 17 GA. (1.5 mm) mm tubular 32 mm (1-1/4") tailpiece, Less overflow holes. Faucet Supplies, Chrome plated finish polished brass, commercial duty 1/4 turn ball valve angle stops, 13 mm (1/2") I.D. Inlet x 127 mm (5") horizontal extension tubes, convertible 1/4 turn/loose key handles, Escutcheon and flexible copper risers. Heavy cast brass adjustable body, with slip nut, 32 mm (1-1/4") size, Shallow wall flange and Seamless tubular wall bend.

Fixture Carrier, mounted on concrete floor, steel hanger plate, heavy gauge epoxy coated steel offset uprights with welded feet supports. For one unit: 102 mm (4") for two to six units in a row: 152 mm (6") finished metal stud wall to back of pipe space.

.2 Standard of Acceptance:

Bowl:	Franke Commercial WHB Series #WHB1819-7
Faucet:	Chicago Faucets #50-E35-317XKABCP
Mixing Valve:	Lawler #570-86820
Drain:	McGuire #PRODRAIN Open Grid Drain
Trap:	McGuire #8872C P-Trap
Supplies:	McGuire #LFH170BV
Carrier:	Watts #CA-311 Fixture Carrier

.9 S-8 (Kitchen - Triple Bowl Sink)

.1 Sink basin supplied by another division. American Standard Pekoe Single handle Faucet, Polished Chrome finish, Center hole only, Brass body, 1/4 turn washerless ceramic disc valve, 5.7LPM (1.5 GPM) aerator outlet (aerator to be removable and replaceable), Brass swing spout and swing arm metal hose and protector coil, 254 mm (10") projection reach, Lever handle, Pull-down spray with adjustable spray pattern. Point Of Use Thermostatic Water Mixing Valve, nickel plated bronze body, temperature adjusting spindle, 10 mm (3/8") inlets and outlet FNPT connections, Integral checks, offer temperature range between 35 °C (95 °F) and 46 °C (114.8 °F). Set valve temperature at 40 °C (104°F). Provide tee, adaptors and flex. copper tubing to suit installation. Provide tempered water to hot side of faucet. Faucet Supplies, 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. Provide P-Trap, same material as the connecting pipe drain.

.2 Standard of Acceptance:

Faucet:	American Standard Pekoe #4332.350.002
Mixing Valve:	Lawler #570-86820
Supplies:	McGuire #LFH165LKN3

.10 S-9 (Kitchen – Countertop Mount Double Bowl Sink c/w EW-3)

.1 794 mm (31-1/4") wide x 522 mm (20-9/16") long x 254 mm (10") high deep, Counter mounted, backledge, Grade 18-10 18 GA. (1.2 mm) 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" (89 mm) crumb cup waste assembly with 1-1/2" (38 mm) tailpiece.
Custom (non-returnable), specify hole drilling. Two handles Faucet, chrome plated finish, ECAST construction lead free (equal or less than 0.25%) Cast brass body, Quaturn compression operating cartridge, 3.8 LPM (1.0 GPM) vandal resistant pressure compensating Softflo aerator

outlet, 133 mm (5-1/4") projection rigid/swing gooseneck spout, 102 mm (4") metal vandal proof wrist blade sixteen point tapered broach handle with blue and red index buttons. Faucet Supplies, 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. P-Trap, heavy cast brass adjustable body, with slip nut, 38 mm (1-1/2") size, Box flange and Seamless tubular wall bend.

.2 Standard of Acceptance:

Bowl:	Franke Commercial #LBD6410PCB-1
Faucet:	Chicago Faucets 1100 Series #1100-G2E35-317AB
Trap:	McGuire #8912CB P-Trap
Supplies:	McGuire #LFH165LKN3 Faucet Supplies

2.5 Emergency Eye/Face Wash

.1 EW-1 (Mechanical Room)

.1 Wall mounted, eye/face wash, 11 1/2" (292 mm) diameter, stainless steel bowl, two (2) FS-Plus spray heads with fliptop dust cover and filter, powder coated cast aluminum flag handle activation, 1/2" (13 mm) IPS chrome plated brass stay-open ball valve with Teflon seal, heavy duty cast aluminum wall bracket with corrosion resistant powder coated finish, chrome plated brass tailpiece and trap with 1-1/2" (38 mm) IPS waste connection, 1-1/4" (32 mm) NPT female outlet - Unit is third party certified by IAPMO to meet ANSI Z358.1-2014, the Uniform Plumbing Code cUPC and the National Plumbing Code of Canada. Eyewash/Facewash fixture should be installed 4 to 10 feet from the mixing valve. For Emergency Thermostatic Mixing Valve, Lawler model # 911E/F Provide shut-offs at emergency mixing valve. Emergency Thermostatic Mixing Valve for Eyewash or Eye/Face Wash, lead-free brass and stainless steel design, vandal-resistant temperature adjustment, stainless steel sliding piston control device allow cold flow through both the fixed and variable bypass, 13 mm (1/2") 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 psid. (See 911E/F) Provide shut-offs at emergency mixing valve

.2 Standard of Acceptance:
Eye Wash Unit: Guardian #G1750-T
Emergency Tempered Water Mixer: Lawler #911E/F

.2 EW-2 (Counter Mounted)

.1 Guardian, left mount with left offset, Counter mounted polished chrome plated brass construction, eye wash, two (2) GS-Plus spray heads with fliptop dust cover, internal flow control and filter, furnished with in-line

strainer to protect valve and spray heads from debris in water line, AutoFlow swing-down activation, 1/2" (13 mm) IPS plug-type valve with Teflon coated O-ring seals, Type 316 stainless steel valve housing mount on countertop behind sink (furnished with mounting hardware for securing unit to counter) - Unit is third party certified by IAPMO to meet ANSI Z358.1-2014, the Uniform Plumbing Code cUPC and the National Plumbing Code of Canada. For Emergency Thermostatic Mixing Valve, Lawler model # 911E/F Provide shut-offs at emergency mixing valve.

.2 Standard of Acceptance:
Eye Wash Unit: Guardian #G1849LH-L
Emergency Tempered Water Mixer: Lawler #911E/F

.3 EW-3 (Faucet Mounted)

.1 Guardian**,** faucet mounted, eye wash, outlet heads are mounted 5" (127 mm) apart and angle forward and inward toward user, angle adjustable and furnished with float-off dust covers, pull and push knob, forged brass diverter valve - Faucet-mounted eyewashes require two motions to operate (turn on water, pull knob to activate eyewash flow. Therefore, Guardian does not believe that these units meet the provisions of ANSI Z358.1-2014 as eyewash units in addition to dedicated, plumbed, eyewash equipment installed in the workplace. Faucet mounted eyewashes should be used with cold or warm water ONLY, hot water may cause scalding. For Emergency Thermostatic Mixing Valve, Lawler model # 911E/F Provide shut-offs at emergency mixing valve.

.2 Standard of Acceptance:
Eye Wash Unit: Guardian #G1101
Emergency Tempered Water Mixer: Lawler #911E/F

2.6 Thermostatic Shower Valve Set

.1 Chicago Faucets TempShield #2500-VOCXKCP-CP Thermostatic Shower Valve set, chrome plated finish, oval shaped trim face plate, Top lever handle for on/off volume control and bottom lever handle to set desired temperature, Integral check stops, ceramic cartridge for on/off control, Integral check stops. **Niagara N2912CH**, Chrome plated finish, 4.8 LPM (1.25 GPM) flow rate @ 80 psi, Pressure compensating flow control device, Swivel ball joint. Chicago Faucets #749-016JKCP/415-021JKCP Wall Mount Shower Arm, Round escutcheon. Chicago Faucets #624-CP-CP Adjustable Hand Shower, 9.5 LPM (2.5 GPM) flow rate @ 80 psi, Pressure compensating flow control device. Chicago Faucets #9800-024CP Hand Shower Grab Bar/Slide Bar Combination, Chrome plated finish Stainless steel construction, 38 mm (1-1/2") dia x 610 mm (24") high bar, Adjustable bracket for personal shower, locking wall flanges, Includes mounting hardware. Chicago Faucets #24-69NF Hand Shower Metal Hose 1801 mm (70.9") long. Chicago Faucets #E24JKCP Hand Shower In-Line Vacuum Breaker, Installed between supply outlet and shower hose, maximum hot water temperature of 60 °C (140 °F), maximum working pressure of 861.25 kPa PSI. Chicago Faucets #622-001CP Hand Shower Wall Supply, Chrome plated finish, 13 mm (1/2") NPT female thread inlet, 13 mm (1/2") hose connection. Chicago

Faucets #763-CP In-Wall 3-Way Diverter Trim and Valve Kit, Metal lever handle, brass valve construction, Rotational control to alternate water flow between three (3) different shower outlets. Watts #FD-100-C-A Floor Drain, epoxy coated cast iron, 5" (127 mm) adjustable round nickel bronze strainer, reversible clamping collar with primary & secondary weep holes.

PART 3 - EXECUTION

3.1 Fixture Installation

.1 Connect fixtures complete with supplies and drains, separately trapped, supported level and square. Hot water faucets shall be on left. Fixtures on outside walls to have supplies from floor; other fixtures to be served from wall.

.2 Provide chrome plated rigid supplies to fixtures with hand wheel stops, reducers and escutcheons.

.3 Fixtures mounted on glazed tile surfaces shall have ground faces to finished surface.

.4 Provide all hangers, supports, brackets, reinforcement and steel back-up plates for proper installation of the fixtures and fittings.

.5 Install all components in accordance with the manufacturer's recommendations.

.6 Where plumbing fixtures contact wall and/or floors, seal joints with Dow Corning 781 building sealant, make watertight and bead smooth in a neat manner.

.7 Provide a trap for each fixture.

.8 Vent all fixtures in accordance with the code.

.9 Fixture mounting heights measured from floor shall be in accordance with applicable regulations. Also see Architectural drawings.

.10 For specific details on mounting arrangement of fixtures, see Architectural drawings.

END OF SECTION

1 General

1.1 DESCRIPTION

.1 This document summarizes the minimum Owner's Project Requirements (OPR) and the Basis of Design (BOD) to support the planning and implementation of Net Zero Energy Building (NZEB) for Mount Dennis Day Care.

1.2 REFERENCES

.1 Specification Section 21 05 01 Mechanical General Requirements

.2 Specification Division 23 09 23 – Building Automation System

.3 Specification Section 26 05 01 - Common Work Results – Electrical

.4 Specification Section 01 91 17 General Measurement & Verification (M&V) System

.5 Specification Section 23 21 14 Thermal Energy/BTU Meter

.6 Specification Section 26 09 13 Digital Metering System

.7 City of Toronto: Building Automation System (BAS) Information

.8 City of Toronto Cabling and Security Information

1.3 INTENT & OVERVIEW

.1 For a building to achieve Net Zero Energy and Zero Carbon Emissions, it must involve four key components:

.1 The building demonstrates a zero-carbon balance in its operations.

.2 Design prioritizes reducing energy demand and meeting energy needs efficiently

.3 Onsite renewable energy is used

.4 The embodied carbon of the structural and envelop materials is evaluated part of the design

.2 The purpose of an M&V is document the actual performance of the Mount Dennis Daycare against the goals of Net Zero Energy Building (NZEB), while providing a detailed analysis of the relative contribution of the various strategies employed.

.3 A whole building verification approach is required, that is consistent with the building's Net Zero Carbon goals. Sub-systems and occupancy will be monitored in order to determine the performance of each system against the predictions that are based on the energy model.

.4 The actual and predicted building performance will be compared. Discrepancies will be studied and appropriate corrective actions will be recommended in order to enable the Owner to maximize the energy performance of the facility.

.5 This document and all referenced Appendices form part of the Division 26 also known as Digital Metering System (DMS).

.6 The M&V system will integrate permanent energy monitoring system and real-time energy analysis tools to allow building owner to track energy consumption, track energy generation, detect faulty equipment operations, and identify unusual energy or power consumption patterns as they occur.

.7 The M&V system will ensure that adequate sub-metering system, operational points trending capability of HVAC equipment parameters and determine action plan for identifying and correcting operational errors, deficiencies, including the ongoing documentation of an issue log.

.8 All sampled data is stored on the DMS computer or the DMS cloud server.

.9 This data is to be available to the Owner and Consultant for download and delivery through a virtual private network (VPN), remote desktop connection, file transfer protocol (FTP) or other previously and mutually agreed-upon electronic means.

2 Requirements

2.1 SCOPE

.1 Achieving Net Zero Energy and Zero Carbon Emissions are the responsibilities of the Consultant. M&V activities include preparation of M&V plan, review design drawings and control schematics for appropriate meters and trends, NZEB related construction administration, NZEB related commissioning, and M&V reporting. Throughout the project, the Consultant will coordinate NZEB related matters with the Design Team, Construction team, DMS contractor, Controls Contractor and Owner's Representative. The M&V Consultant shall be independent of the work of design and construction.

.2 This specification covers the provision for on-site data storage of building systems energy consumption and performance data which will be required in order to achieve Net Zero Energy Building (NZEB) status.

2.2 MINIMUM METERING REQUIREMENT

.1 Energy and water systems must be designed in such a way as to enable energy and water monitoring for the purpose of determining overall system performance.

2.3 BUILDING-LEVEL MAIN UTILITY METERS

.1 Water:

.1 To support water and energy management, identify opportunities for additional water savings by tracking building level water & energy consumption to ensure that water and energy consumptions are optimized at the building level,

.2 Install permanent water meter to measure the total potable water use of the entire building and the associated grounds.

.3 The main meter data to be compiled and recorded at least a monthly basis and annual summaries to be prepared.

.4 Recording meter readings can be manual via monthly utility bill or automated. However, we are recommending meter readings to be collected and archived automatically via remote transmission by the central metering system software.

.5 Note: If the local public water utility company restricts access to the main incoming water meter data or uses proprietary remote reporting technology, the project team may meet the building-level water meter requirement by tracking water usage through monthly billing.

.6 However, to collect more frequent or accurate data, the project team has decided to replace the existing public main water meter and/or install a private water meter downstream of the public water supply meter.

.7 If the main incoming water meter is owned by the building owner, the meter vendor must provide factory-calibration certificate confirming that this water meter is calibrated and certified to the National Conference on Weights and Measures (NCWM) regulatory standards and hence approved for utility billing and commercial metering.

.2 Energy:

.1 Similarly, permanent energy meters need to be installed to measure the total building energy consumption (electricity, as applicable for Mount Dennis Day Care). Note that utility-owned meters capable of aggregating building-level resource use are acceptable.

.2 Utility-owned meters capable of aggregating building-level resource use are acceptable.

.3 NOTE: if the local utility company restricts access to the meter or uses proprietary remote reporting technology, the project team may meet the Building-Level Energy Metering requirements by tracking energy usage through monthly billing.

.4 However, to collect more frequent (i.e., hourly interval data) and accurate meter data, and to automatically trend-log and archive all these main incoming meter data by a central metering system (e.g., DMS) via remote transmission, the Mount Dennis Day Care project team may need to decide to install a private energy meters downstream of the local utility company meters. All these main incoming meters shall be revenue grade, and supplied with shop test calibration certificate and commissioning report after installation and on-the programming.

.3 The following building-level equipment and systems should be integrated into the DMS along with the more traditional heating, ventilating and air conditioning elements comprising energy and water system:

.1 Total building electricity consumption (Totalized kWh), peak demand (kW) and power factor.

.2 Total building potable water consumption.

.3 On-site PV generation

2.4 SYSTEM LEVEL SUB-METERING SYSTEM

.1 Sub-metering the major building water and energy systems provides a way to benchmark water and energy usage, formulate a reference baseline, track usage against the baseline, isolate and identify potential sources of waste, and take corrective action. Moreover, sub-metering helps track periodic changes in water usage and provides the data necessary to calculate opportunities for water savings at a system wide level

.2 Recommending dedicated sub-metering and monitoring of the following energy and water end-uses:

.1 Electric Sub-Metering System:

Provide a networked digital metering system to monitor electrical loads and quality of power in the Facility. System to be part of the central electrical metering & monitoring system.

.1 Incoming main from Toronto Hydro Power Supply

.2 Distributed Generation System from the Photovoltaic Panels

.3 Distribution Panels, 600V and 208V as follows:

.1 Input to Panel DP6B

.2 Input to Panel SB upstream to TX-2

.1 Battery Storage

.3 Input to Panel DP2B upstream to TX-1

.1 Panel M

.2 Panel 2A

.3 Panel BA

.4 HVAC Fans: no meter required since kWh data can be collected from the Building Automation System via VFD and/or runtime.

.5 HVAC pumps: no meter required since kWh data can be collected from the Building Automation System via VFD and/or runtime.

.6 Water Distribution pumps: no meter required since kWh data can be collected from the Building Automation System via VFD and/or runtime.

.7 Elevators: Branch Circuit Sub-Metering using temporary spot metering

.8 Exterior lighting: To sub-meter five (5) branch circuits to monitor exterior lighting consumption in panel BA.

.9 Domestic Hot Water Energy for DHW-3: By Branch Circuit Sub-Metering in Panel DP6B.

.10 Input to water-to-air Heat Pumps (HP 1 ~ HP 15) – to account for cooling energy consumption. Please note that Integrated refrigerant monitoring allocation systems are acceptable for refrigerant based (VRF) systems, provided the heat pump supplier has the software to provide this kWh input electricity consumption and equivalent thermal energy output serving the building.

.11 Air Compressor: To be sub-metered via Branch Circuit Sub-Metering in Panel M.

.12 Electricity consumption of HRU-1: By Branch Circuit Sub-Metering

.13 Laundry Dryer and washer: By Branch Circuit Sub-Metering of five (5) Branch Circuits in panel 2A.

.2 Thermal Energy:

.1 Total Geothermal energy serving the building HVAC (HPR & HPS Loop)

.2 Geothermal Ground Heat Exchanger Loop (GHXR & GHXS loop across pumps P-3/P-4)

.3 Heating water output energy from the Heat Pump Loop serving building HVAC on the secondary side of Storage Tank T-1serving building HVAC

.4 Ventilation air conditioning energy serving HC-1 for HRU-1

.5 DHW pre-heat energy from the solar thermal and geothermal loop

.6 Solar thermal energy from Solar Thermal PV/T Loop serving building HVAC on the secondary side of HE-2 (Across pumps P-9)

.3 Water Sub-Metering

.1 Total Water Consumption for the whole facility

4. Energy end-uses can be excluded from the sub metered list if the end-use represents less than 10% of total annual energy consumption, as determined from detailed design-phase energy modeling. Where multiple sources of energy make up an end-use, this criterion refers to the total end-use.

.5 Where more than one meter is required to measure a given end-use type, include a virtual meter point to represent the aggregate load. For heat pumps, include virtual meter points for energy consumption for space heating and for space cooling.

2.5 PERFORMANCE EFFICIENCIES

.1 Desired performance data are as follows that are derived from the System Level Energy Meter data:

.2 Heat Pump coefficient of performance (COP) will be calculated using Equation 1

COP = Output Thermal Energy ÷ Input Electricity	Equation 1

2.6 HVAC CONTROLS AND OPERATION MONITORING POINTS

.1 In addition to the Building level Utility Meters and System Level sub-meters, keep provisions including but not limited to the following HVAC controls and monitoring points trend-logs from the Building Automation System as follows to support M&V activities:

.1 Variable frequency drive (VFD) pumps and fans: monitor via BACNet integration motor speed and average kW demand over 15-minute intervals and all corresponding control point values, e.g., duct static pressure or water differential pressure.

.2 Pumps and Fan without VFD: monitor ON/OFF status to derive totalized runtime or collect ampere readings (if a current transformer is installed) at 15 minutes interval to calculate totalized kWh from stipulated Voltage reading and power factor on the BAS.

.3 Air handling systems: monitor outdoor and mixed air damper positions, mixed and supply air temperatures, duct static pressure, and return air CO_2 levels (when demand control ventilation strategy is implemented)

.4 Air flow measurement of HRU-1 in L/s and totalized (m^3)

.5 Passive Ventilation heat recovery (i.e. glycol run around or heat wheel) on air systems: monitor outside air temperature (t1), temperature of outside air leaving the heat wheel (t2), temperature of inside air entering the heat wheel (t3), calculated value for heat recovery effectiveness ($\varepsilon = (t2 - t1)/(t3 - t1)$)

.2 For all systems identified above, include additional monitoring of relevant DDC points to further characterize system performances as deemed appropriate.

.3 For HVAC monitoring data trending and software requirements, the attached Table E3 and E5 from ASHRAE 13-2015 can be referred for Best Practice.

2.7 DELIVERABLES

.1 For the purposes of M&V, the meters, Digital Metering System and BAS shop drawings must be approved by Owner's representative M&V Consultant, DMS supplier, BAS Supplier and Mechanical & Electrical Designer.

.2 Provide a list of the meters to be archived by the DMS and BAS in the relevant shop drawings.

.3 Provide a list of the points to be archived by the BAS in the controls shop drawings.

.4 Provide a sample output data file a minimum of 1 month prior to building occupancy.

.5 Provide data files to Owner's Representative and M&V Consultant in electronic format.

2.8 SYSTEM SOFTWARE

.1 Provide a Windows™ based simplified user interface for system operation.

.2 Software shall be provided, capable of accomplishing the following functions:

.1 Software shall store all data in comma separated variable (.CSV) file format.

.2 Meters and monitoring point data are to be read or recorded at every 15 minutes interval or less.

.3 The software shall allow the user to view instantaneous readings of voltage, current, power, **totalized energy consumption (kWh)**, phase angle, present and peak **demand data (kW)** for any electricity meter.

.4 Similarly, the software shall allow the user to view the totalized consumption of domestic cold water consumption (m^3), Supply & Return temperature (°C) and calculated totalized kWh or GJ reading for all Thermal Energy/BTU meters as applicable.

.5 Whole building electricity meters should record the power factor.

.6 Software shall have the ability to export data into Reporting Applications (e.g. Web, .csv., Excel and notepad)

.7 Software shall store metering and monitoring data for a period of no less than 36 month, measured from the date of substantial occupancy and commissioning when a reasonable degree of operational stability has been achieved.

.8 Software shall include service menus for diagnostic monitoring of the metering equipment and through Virtual Private Network (VPN) access to permit remote diagnostics by the manufacturer's service technicians. Security access control shall permit remote diagnosis to be locked out.

.9 The central metering and monitoring system will have the following three (3) levels of capability:

.1 Data collection and Trending: Collects and trends raw data against a time-stamp, preferably in Tabular format and graphical format. Energy and water consumption of various electricity, heating water energy will be measured using one of the following methods:

.1 Calculated data based on equipment runtime together with rated power draw/ ampere readings from current transformer collected from and calculated on the BAS

.2 Calculated energy data directly collected form the VFDs on the BAS

.3 Assumed energy usage of fixed/steady loads calculated over the reporting period based on nameplate/TAB data, stipulated key parameters (e.g., runtime, operating schedule etc.,) and using assumed usage factors (e.g., demand factors, power factors etc.). All calculated data will be trended and displayed on the BAS. Few virtual meters and meter data grouping can be done as follows:

.1 Meter all similar systems together. This strategy is appropriate for multiple systems that serve the same type of occupant and operate according to the same schedule.

.2 Meter all similar systems separately. This strategy is appropriate if each system serves a different type of occupancy group or has a different operating schedule.

.3 Meter similar systems by grouped occupancy type or operating schedule. This strategy is a combination of the above.

.4 Create virtual meters to trend the calculated meter data by subtraction and/or summation for ease of analysis and reporting purposes

.5 This will identify changes in consumption or demand or operational hours for major end uses and building level usage.

.2 Trending Data Analysis: Data collected in the form of time-value trend logs can be analyzed by either creating X-Y plots and be able to export these data to a third-party graphing and analysis tool e.g., Microsoft Excel.

.1 Using this information, building operators can implement a controls sequence in the BAS or energy management system that predicts the expected energy consumption and peak demand for different temperatures in occupied and unoccupied conditions.

.2 The anticipated consumption and peak should be determined by analyzing historical facility performance and weather and operating conditions and should be set on at least monthly, preferably daily.

.3 On monthly basis, the BAS shall report the facility's utility peak demand and total consumption and compare it with the data for the previous month and the same month from the previous year.

.4 This will identify if equipment are operating "after hours" or during "un-occupied hours", weather temperature setbacks are working for HVAC system, identify changes in usage profile over weekend, weekdays,

.3 Equipment fault Diagnosis and Event Response: Data collected and analyzed can be used to identify and predict mechanical, electrical or other equipment faults or can provide analysis of data relating to operational issue, power quality etc. Few examples include to predict energy consumption and demand patterns to prepare demand response strategy, provide automated report on the impact on building health, send alerts related to alarms, etc.

.1 Thereafter the facility's energy management system can be programed to set an alarm whenever the actual energy consumption and peak demand rise above the anticipated amount by more than say 5%.

.2 Will calculate Plant efficiencies, effectiveness, COP, EUI/, WUI, Cost Index, Greenhouse Gas index etc., for analysis purposes, and be able to provide relationship of energy and water use with independent variables (e.g., HDD, CDD, Occupancy etc.)

.3 Help to identify problem areas, optimization opportunities and track results after corrective actions are implemented.

.4 The DMS/BAS will generate reports to provide monthly energy use summary. The sample reports will be provided once the Controls

Shop Drawing, DMS shop drawing are available, the final meter list is finalized and the Owner can provide their requirement.

3 Data Requirements

3.1 DURATION

.1 The system must be capable of storing all interval meter data for at least 36 months.

3.2 REQUIRED MONITORING POINTS

.1 A Required Monitoring Points List will be provided. Essentially, the data will include all electrical meters and Thermal Energy meters tied to the digital metering system (DMS), HVAC's monitoring and control points from the building automation system (BAS) and totalized energy (kWh) data for exterior and interior lighting system from the Lighting Control System (If any). The DMS/BAS must be capable of storing all meter and monitoring point data for at least 36 months. See Appendix C for tentative metering and monitoring points.

.2 All meters and HVAC system control & monitoring points must be shown in the relevant design drawings e.g., electrical single line diagram, electrical panel schedule. HVAC schematic drawings (i.e., Plumbing, heating hot water, Controls schematic drawings)

.3 All points being stored shall follow the format outlined in Section .3 OUTPUT FILE FORMAT & STORAGE.

3.3 OUTPUT FILE FORMAT & STORAGE

.1 Data shall be recorded every 15 minutes interval or less, so that the DMS and BAS can record totalized energy use and/or totalized equipment runtime (hours) by tracking time intervals between individual "change of value" (COV), if any) with its trending capability.

.2 All meter and monitoring point data shall be available in comma separated value (.CSV) files.

.3 Each row in the output file shall represent a successive sample time.

.4 Include a time stamp for each line in the file, e.g., dd/mm/yyyy h:mm:ss AM/PM.

.5 Separate each field by a single comma character.

.6 Each required monitoring point shall contain a unique and understandable identifier.

.7 Each required monitoring point shall be identified with a unique and understandable column.

.8 All output files are to follow the format shown in Appendix A as closely as possible.

.9 All recorded data is to be stored on the centralized data warehouse.

.10 Provide a sample output data file a minimum of 1 month prior to building occupancy.

.11 Provide data files to the Owner and M&V Consultant in electronic format

.12 All meters in the system must be capable of reporting hourly, daily, monthly and annual energy use.

3.4 DATA STORAGE AND LOGGING REQUIREMENTS

.1 System shall be capable of storing data for a minimum of 500 points for a period of no less than 18- months.

.2 Adequate hardware and software capability must be provided for interval metering and monitoring data trending so that it will not compromise the system capacity for the computer processing, communication bandwidth and data storage space. The DMS and BAS shall have adequate processing and storage capacity to handle trending data while supporting the system's control functions.

.3 The DMS and BAS system must have additional capacity for extra trending so that the Facility staff should be can develop their own trending information for diagnosing system problems.

3.5 NETWORK INTERFACE & CONTROIIER

.1 The DMS and BAS Tender price will include the necessary hardware, software and technical labour to connect the system to the owner's enterprise network or Internet.

.2 The data collection system must use a local area network, digital metering system, building automation system, wireless network, or comparable communication infrastructure.

.3 The data must be remotely accessible.

.4 The owner shall provide a connection to the Internet to enable remote access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the owner's Intranet to a corporate server providing access to an Internet Service Provider (ISP). The owner shall pay any monthly access charges for connection and ISP.

.5 The owner will establish a Virtual Private Network (VPN), remote desktop, file transfer protocol (FTP) or other previously and mutually agreed-upon electronic means to allow M&V Consultant to access the metering data remotely for M&V purposes.

3.6 FIELD METERS:

.1 Electrical Meter: See Details in Section 26 09 13

.1 All electrical meters to be Revenue Grade and hence Measurement Canada Approved for accuracy (i.e., IEC 0.2S accuracy Class). However, except for the main incoming, none of the electrical sub-meters needs to be sealed.

.2 For electrical sub-metering additional metering panels and high density multi-tenants metering hardware are preferable to reduce cost.

.2 Thermal Energy/BTU Meters (See Details in Section 23 21 14)

.1 Thermal Energy/BTU meters shall be provided by Division 23 (Mechanical)

.2 Thermal Energy/BTU meters shall be a "True" energy meters capable of measuring flow rates from flow sensors as well as measuring supply and return temperatures from the two temperature sensors and computing energy consumption using the field level energy computer.

.3 Thermal Energy/BTU meters shall conform with Canadian Standards Association (CSA) C900 Heat Meter Standards or the European Committee for Standardization (CEN) Standard EN 1434.

.4 Communications cable from meters to DMS computer location shall be provided by Division 26 (Electrical).

.5 All Thermal Energy/BTU meters shall be inter connected by a network connected to the DMS computer.

.6 Provide interface equipment as required to connect the thermal energy/BTU meters to the DMS computer.

3.7 COMMISSIONING, FIELD VERIFICATION, ACCEPTANCE

.1 Coordinate installation of all meters with relevant trades (electrical, mechanical, plumbing) making wiring connections between meter and the DMS/BAS, namely control/data communication and power connections (as required). Install separate conduits of appropriate size as specified by electrical designers for running data communication wiring and power cables.

.2 For any inline meters if there is a possibility of restricting the normal fluid flow due to the malfunction of meter itself, then a by-pass line with shut-off/isolation valves are recommended for avoiding any system shutdown due to meter malfunction. A bypass line is not required for insertion type meters that can be removed without shutting off the system.

.3 Installation contractor shall provide “AS BUILT” – marked up by meter vender; “Record of Metering Installation” sheet(s) indicating each meter make & model number, serial no., address, configuration for units of measurement, configuration of multipliers, confirmation that meter is recording and trend is set up, cross-reference with monitoring point name, metered tenant(s) and other applicable information. Information to be forwarded to software or reporting vender (i.e., DMS, BAS).

.4 All mechanical and electrical meters shall be installed, wired, setup, programmed and commissioned by approved meter manufacturer or by their designated trained personnel.

.5 All wiring will be done in accordance with Canadian National Electric Code standards and regulations, and in conjunction with the local Electrical Safety Association office.

.6 Sample Meter Connectivity and Responsibility Matrix for Installation and Wiring is provided in Appendix D.

.7 Commission all meters and the digital metering system by the meter manufacturer or by their approved representative and/or by the DMS contractor to the satisfaction of the owner and the M&V Consultant and demonstrate the proper functioning of the metering system. Each meter and monitoring point must be verified for correct units of measurement, reading over full operational range, correct calculated value, and adherence to monitoring point labelling convention. Includes Meters and HVAC system monitoring points. DMS and BAS data and trending functionality must be demonstrated for each M&V monitoring point.

.8 Provide records of configuration and/or formal commissioning certificate/report for each meter and monitoring point. Record of configuration must include the following information at a minimum: configuration for units of measurement, equation for calculated values (If any), confirmation that monitoring point is recording reliable and accurate data, trend is set up, all interval trend-data are archived properly being cross-reference with monitoring point name.

.9 Meter vender’s representative shall verify, adjust and test the system to ensure proper installation and communication. Verification to be carried out with the assistance of the contractor(s). Upon completion, vender to issue a “CERTIFICATE OF ACCEPTANCE” to the owner, consultant(s) and contractor(s).

.10 Demonstrate and confirm that the all meter data physically recorded on the field level meter’s LCD panel or read-out display are the same readings integrated, trend-logged

and archived on the DMS with proper time stamp, unit of measurement, correct meter ID, at 15-minute's interval and archived on the historical database for at least 18-months and as required for M&V.

.11 Prepare a meter functional test reporting template in consultation with the commissioning agent and successful meter vendor and fill out and sign after successful completion. A sample template is attached in Appendix B.

.12 The Functional Test shall document that the energy source meters, end-use meters, the metering data acquisition system, metering consumption display are calibrated, adjusted and operate with approved commissioning plan and specifications. The Functional Testing of metering system, at a minimum, shall confirm the following:

.1 The metering system devices and components work properly under low and high load conditions;

.2 The metered data is delivered in a format that is compatible with the data collection system of the DMS.

.3 The energy and consumption display is accessible to building operations, management personnel and designated consultants.

.4 The display shows energy and consumption data in identical and agreed upon unit of measurement with proper output format

.13 Vender representatives shall demonstrate operation of the system as follows:

.1 Meter readings at the meter

.2 Diagnostics

.3 Provide manual of installed system.

.14 Provide M&V consultant with remote access to the DMS database.

.15 All meters installed by the owner must be maintained and calibrated at a frequency per the manufacturer's recommendations. The Main incoming Utility energy meter sealed and used for utility billing is exempted for calibration by facility owner.

3.8 TRAINING

.1 DMS vendor representative shall provide a training session to the owner's staff and owner's consultant. It shall be minimum of four on-site hands-on field training and classroom training sessions, three days each throughout the contract period for personnel designated by the owner.

.2 The DMS training instructor shall be factory-trained instructor experienced in presenting the installed Central Metering and Monitoring System.

.3 The DMS vendor shall provide a training plan including hours of instruction, course outlines and training materials to meet the owner's need. The training will be based on the following:

.1 System training including configurations, programming, customization, e.g., setting up trends

.2 GUI, dashboard and tool customization

.3 Monitoring and Operations

.4 Maintenance and troubleshooting

.5 Administrative and system management

.4 DMS vendor representative shall demonstrate and confirm that the all meter data on the field level meter's LCD panel or read-out display are the same readings integrated, trend-logged and archived on the DMS.

.5 DMS vender representative shall demonstrate operation of the metering and monitoring system as follows:

.1 Meter readings physically recorded at the meter on the field level LCD panel or read-out display are the same readings integrated, trend-logged and archived on the DMS

.2 Demonstrate fault detection and diagnostics e.g., alarms, alerts, emails or any custom algorithms.

.3 Show that all meter data are trended with proper time stamp, correct unit of measurement, correct meter identification labels, at 15-minutes or less and archived on the historical database for at least 36-months as required for M&V.

.4 Provide operation and maintenance manual of installed metering and monitoring system.

.5 Provide factory shop-test certificates of all meters

.6 Provide commission reports of all meters and metering system

.6 Training will be applicable for new and existing staff on using the Central Metering and Monitoring System implementing the on-going monitoring action plan, and conducting any required training when system settings are changed. The topics covered in the training will include the following:

.1 Key performance indicators (KPI) and analytics that will be tracked in the Central Metering and Monitoring System.

.2 Central Metering and Monitoring System functionality that will be used to track those KPIs

.3 Current Facility Requirements and control sequences of operation

.4 What to review in the Central Metering and Monitoring System to find performance issues or areas for improvement

.5 Meter and critical sensor calibration requirement, frequency etc.

.6 Troubleshooting data quality issues

.7 Central Metering and Monitoring System capabilities and navigation

.8 Training on building systems' improvements

.7 General contractor/DMS contractor shall video tape the training session(s) and keep records to training attendances.

3.9 CALIBRATION OF METERS AND SENSORS

.1 Meter vender will be accredited by Measurement Canada to complete S-E-04 inspections on metering devices installed on various end-uses required for billing purposes.

.2 All meters, sensors and associated instrumentations shall be factory calibrated. Provide shop test calibration records/calibration certificates of all meters and sensors from the meter manufacturer. In addition to the above, provide relevant meter sizing calculation of Thermal Energy Meters, natural gas meters and steam meters from the relevant meter manufacturer while purchasing individual meters.

.3 Sensors and metering equipment shall be selected based in part on the ease of calibration and the ability to hold calibration. An attractive solution is the selection of metering equipment and sensors that are self-calibration, if possible. Otherwise, all meters and sensors must be installed in such a way as to facilitate periodic calibration without interruption of system operations.

.4 Provide records of on-site calibration of all meters confirming that correct multipliers were used while programming the meter data on the DMS to read and archive accurate meter data.

.5 Meters and sensors must be installed in such a way as to facilitate periodic calibration without interruption of system operations. Frequency of calibration is per manufacturer requirement. On-going calibration of owner's meters and sensors is the responsibility of the owner.

.6 All meters installed by the owner must be maintained and calibrated at a frequency per the manufacturer's recommendations. The Main Incoming Utility energy meter sealed and used for utility billing is exempted for calibration by facility owner.

3.10 WARRANTY

.1 All equipment shall be free from defect in materials and workmanship under normal use and service for the period of twelve (12) months from the date of substantial commissioning of metering system on the DMS.

.2 All equipment will be verified by a factory-trained technician and certified for its Revenue Class accuracy.

.3 A certificate shall be issued on final completion to confirm that the system is operating according to specifications.

23 05 11 - APPENDIX A: SAMPLE METERING OUTPUT FILES

SAMPLE METERING OUTPUT FILE FOR ELECTRICAL METERING

Date / Time	kWh	kW	kVA
8/29/2008 1:00	14027.17	7.5	0.3
8/29/2008 1:15	14026.22	8.1	0.8
8/29/2008 1:30	14023.25	7.3	1.0
8/29/2008 1:45	14021.45	5.3	1.0
8/29/2008 2:00	14020.02	3.5	1.0
8/29/2008 2:15	14019.15	2.4	0.9
8/29/2008 2:30	14018.56	1.9	0.8

SAMPLE M&V OUTPUT FILE FOR TOTALIZED BTU METER DATA

Date / Time	Supply Fluid Temperature °C	Return Fluid Temperature °C	Flow Rate L/hr	Totalized Energy kWh
8/29/2008 1:00pm	175.25	150.21	7.51	14027.17
8/29/2008 1:15pm	18550	165.21	8.11	14045.21
8/29/2008 1:30pm	190.51	185.21	9.31	14073.21
8/29/2008 1:45pm	215.52	205.21	10.31	14091.41
8/29/2008 2:00pm	220.53	215.25	11.51	14120.01
8/29/2008 2:15pm	245.54	235.54	12.41	14149.11
8/29/2008 2:30pm	255.50	245.23	14.91	14458.51

SAMPLE M&V OUTPUT FILE FOR TOTALIZED KWH DATA FROM CURRENT TRANSFORMER (CT), VFD SIGNALS AND % STATUS

Date / Time	Totalized kWh For P-1 From CT	Totalized kWh For P-2 From CT	Totalized kWh For P-3 From CT	Totalized kWh For P-4 From CT	Totalized kWh For P-5 From CT	Totalized kWh For HRU-1 From VFD
8/29/2008 1:00	14027.17	150.21	7.51	1.25	14027.17	11.25

Date / Time	Totalized kWh For P-1 From CT	Totalized kWh For P-2 From CT	Totalized kWh For P-3 From CT	Totalized kWh For P-4 From CT	Totalized kWh For P-5 From CT	Totalized kWh For HRU-1 From VFD
8/29/2008 1:15	14045.21	165.21	8.11	2.50	14045.21	22.50
8/29/2008 1:30	14073.21	185.21	9.31	3.51	14073.21	33.51
8/29/2008 1:45	14091.41	205.21	10.31	4.52	14091.41	44.52
8/29/2008 2:00	14120.01	215.25	11.51	5.53	15120.01	55.53

SAMPLE M&V OUTPUT FILE FOR TOTALIZED RUNTIME DATA

Date / Time	Totalized Runtime of Pump P-1 Hours	Totalized Runtime of Pump P-2 Hours	Totalized Runtime of HRU-1 Supply Fan Hours
8/29/2008 1:00	14027.17	150.21	1.25
8/29/2008 1:15	14045.21	165.21	2.50
8/29/2008 1:30	14073.21	185.21	3.51
8/29/2008 1:45	14091.41	205.21	4.52
8/29/2008 2:00	14120.01	215.25	5.53
8/29/2008 2:15	14149.11	235.54	6.54

23 05 11 - APPENDIX B: SAMPLE METER FUNCTIONAL TEST FORM

67 - TYPICAL ELECTRICAL METERS

PROJECT INFORMATION

Project:	TBD
Project No:	TBD
Report Date:	TBD
Author:	TBD
Email:	TBD
Tel:	TBD

Testing Log

Date	Description of Testing and Participants

EQUIPMENT INCLUDED IN TESTING & SIGN-OFF

Testing Log

Equip. TAG	Description
	Electrical Meters

Sign-off

Name	Company	Signature	Date

This functional performance checklist requires sign-off from the General Contractor, Controls Contractor, and Mechanical Contractor and Commissioning Agent. By signing, the respective party indicates that they are satisfied with the results of the testing and the overall operation of the system.

W

	ITEMS	PASS/FAIL	COMMENTS	
	PRE-TESTING REQUIREMENTS			
1	Approved shop drawing(s) and shop drawing review report(s) of all Electrical meters and DMS. (except the main incoming Electric meter supplied and installed by local Electric Utility Provider)			
2	Shop test certificates of all Electric meters from the meter manufacturer. (Exempted main incoming Electric meter supplied and installed by local Electric Utility provider)			
3	Confirm that all Electric meters are shown on DMS graphics and accurately displayed.			
4	Signed calibration/commissioning certificate submitted by Electrical contractor.			
5	Confirm that installed meter accuracy is consistent with the approved shop drawing			
	METERING AND MONITORING DATA VERIFICATION			
	Metering:			
1	Verify that DMS monitors all meters, and data is trended. Logged and archived.			
2	Note time stamp, units of measurement, data interval and data archiving period.			

3	Note the CT ratio, PT ratio, communication protocol, IP address							
4	Verify that the Device/Object ID are provided for each meter for electrical data							
	FUNCTIONAL TESTING TABLE							
#	**METER ID**	**DESCRIPTION**	**SERIAL# & ESA#**	**LOCATION**	**UNITS**	**INTERVAL**	**TRENDING**	**LOGGING**
1								
2								
3								
4								
5								
6								

64 - TYPICAL THERMAL ENERGY/BTU METERS

PROJECT INFORMATION

Project:	TBD
Project No:	TBD
Report Date:	TBD
Author:	TBD
Email:	TBD
Tel:	TBD

Testing Log

Date	Description of Testing and Participants

EQUIPMENT INCLUDED IN TESTING & SIGN-OFF

Testing Log

Equip. TAG	Description
	Thermal Energy/BTU Meters

Sign-off

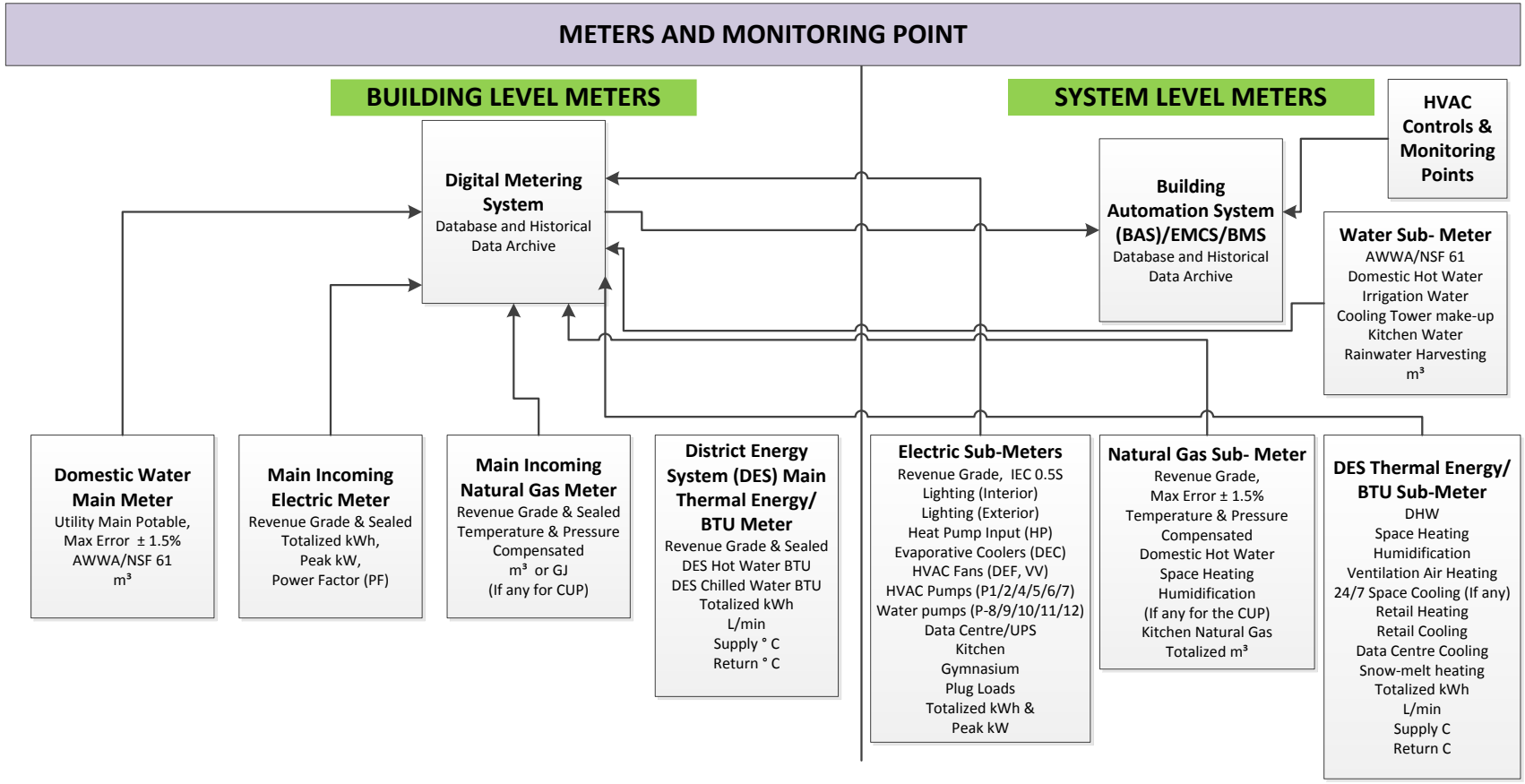
Name	Company	Signature	Date

This functional performance checklist requires sign-off from the General Contractor, Controls Contractor, and Mechanical Contractor and Commissioning Agent. By signing, the respective party indicates that they are satisfied with the results of the testing and the overall operation of the system.

	ITEMS	PASS/FAIL	COMMENTS	
	PRE-TESTING REQUIREMENTS			
1	Approved shop drawing(s) and shop drawing review report(s) of all BTU meters and DMS.			
2	Shop test certificates of all BTU meters from the meter manufacturer.			
3	Confirm that all BTU/Steam Meters are shown on DMS graphics and accurately displayed.			
4	Signed calibration/commissioning certificate submitted by mechanical / DMS contractor.			
5	Confirm that installed meter accuracy is consistent with the approved shop drawing			
6	Confirm that installed meter turndown ratio is consistent with the approved shop drawing			
	METERING AND MONITORING DATA VERIFICATION			
1	Verify that DMS monitors all meters, and data is trended. Logged and archived.			

2	Note time stamp, units of measurement, data interval and data archiving period.							
3	Note the multiplier/Pulse ratio and communication protocol.							
	FUNCTIONAL TESTING TABLE							
#	METER ID	DESCRIPTION	SERIAL# & CRN#	LOCATION	UNITS	INTERVAL	TRENDING	LOGGING
1								
2								
3								
4								
5								
6								

23 05 11 - APPENDIX C: SAMPLE METERING SYSTEM ARCHITECTURE



23 05 11 - APPENDIX D

Table 1: Sample Meter Connectivity and Responsibility Matrix for Installation and Wiring

Type of Meter	Output Unit of Measurement	Make/ Model	Database	Protocol	Division of Responsibility
Electrical Meter	Totalized KWh, Peak KW, KVA Power Factor (pf)	TBD	DMS	Modbus TCP/IP BacNet/IP	Division 26 Install, network and power supply
Thermal BTU Meter	Totalized kWh L/s, °C supply and return Temperatures	TBD	DMS	Bacnet MS/TP to Modbus TCP/IP gateway	Division 20/23/25 install & Division 26 networking and Power Supply

END OF SECTION

TABLE E3 BAS Requirements for Performance Monitoring

Requirements related to:	Related Specification Sections	BAS Elements: Network	BAS Elements: Sensor(s)	BAS Elements: Building Controller or Custom Application Controller	BAS Elements: Central Operator Workstation (OWS) or Enterprise Server	BAS Elements: Historical Data Server
Sensor—certification and O&M requirements	1.5		NIST certified, with calibration data supplied as required.			
Reporting accuracy	1.9	Network should be selected to maximize system throughput. Ethernet is recommended for high speed and high performance.	Sensor accuracy selected to meet end-to-end accuracy requirements. See Table E5 for detailed accuracy requirements.	analog to digital converter(s) in controller support end-to-end accuracy requirements for sensor readings. Minimum 12-bit A/D conversion is required.	The OWS or server may require additional database and structured query language (SQL) software in order to provide custom reports.	
Accurate records	There are no related specification sections for this item. The BAS designer must provide information on the objects to be trended. The BAS designer must also specify the amount of trending in the BAS controller controls as well as which trendlogs need to be long-term trends, as the data needs to be uploaded to the server when the BAS controller controls trendlog buffer is full.	Time sync by server to a standard time sync service. Access to the server clock is restricted by physical and software security measures. Time functions in BAS are synchronized to the system server.		Synchronized (interval) and event-driven trending. Adjustable trend buffer high threshold limit will notify workstation when to upload trend data records from field BAS controls.	Upload trend data from BAS controllers when trend buffer limit reaches high threshold limit.	View data records stored on server. Create reports using historical data server report manager.
Protection of records	The BAS designer must provide language on who is supposed to be backing up the records (i.e., is this a BAS responsibility or will this be done by the facility IT department?).			Battery backup of field controller application programs. Firmware program stored in Electrically Erasable Programmable Read-Only Memory (EEPROM).	Incremental backup of OWS software to designated server hard drive partition. Offload backup of server database to external media. Archiving records is normally done with a separate application provided by the BAS contractor.	Disable data purging. Incremental backup of each hourly transaction log file. Offload backup of server database to external media.
System security	The BAS designer must provide a security plan that specifies user access rights by categories such as guests, technicians, administrators, etc.	Access rights to system records and client applications are all controlled using Windows integrated security.		User account required to access building controller from BAS front end.	Integrated security. Group policy permissions for files and directories are assigned to user groups. OWS user account required to access BAS.	Integrated security or equivalent. Group policy permissions for files and directories are assigned to user groups. Secured access to historical data.

TABLE E3 BAS Requirements for Performance Monitoring *(Continued)*

Requirements related to:	Related Specification Sections	BAS Elements				
		Network	Sensor(s)	Building Controller or Custom Application Controller	Central Operator Workstation (OWS) or Enterprise Server	Historical Data Server
Records—length of retention	Modern BASs with servers have virtually unlimited trending capability. Many BAS vendors have additional applications for archiving data. The BAS designer needs to specify which trendlogs are to be archived and for what length of time.					Historical data retention software locks down records in a secure database and retains them for a user-definable and/or indefinite time.
Written procedures	The BAS designer must either specify these procedures or arrange for these procedures to be provided by others.	The BAS designer should recommend that the following Standard Operating Procedures (SOPs) be developed: backup procedures, calibration procedures, system security procedures, electronic records/data management procedures, incident management procedures, and disaster recovery procedures.				
Control documents	The BAS designer must either specify these procedures or arrange for these procedures to be provided by others.	The customer needs to have the required documentation available and protected. Revision and change control procedures should be in place for all the required documentation. The list of required documentation includes, but is not limited to, operations and maintenance manuals, training records, calibration records, system acceptance and sign-off, and maintenance records.				
Training	The BAS designer must specify the training needed.	The customer will require additional training that is appropriate to the level of performance monitoring specified.				
Ongoing support	The BAS designer must either specify these procedures or arrange for these procedures to be provided by others.	The BAS designer needs to determine if the owner requires ongoing support to maintain the infrastructure or to analyze the data generated by the performance monitoring system. The owner may decide to contract out these services instead of creating additional internal capacity in the facility management organization.				

TABLE E5 BAS Requirements for Performance Monitoring Levels 1, 2, and 3

Requirement	Level 1: Data Collection and Trending	Level 2: Level 1 plus Trendlog Data Analysis	Level 3: Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response
Data Displays			
Software Requirements The BAS designer needs to determine if the BAS supplier can provide the software or if it has to come from another supplier.	Level 1 is specifically designed so that a BAS designer does not have to add additional software. The standard BAS front-end software package will be able to meet Level 1 data display requirements.	The BAS may permit the analysis of the trendlog data from the equipment graphic directly. Otherwise the user may have to launch a separate application and then import the trendlog data as time-value pairs into this application.	It is likely that to meet the Level 3 requirements the BAS designer will have to specify software from third parties that specialize in automated commissioning, FDD, sophisticated metering, and event responses.
Equipment/System Graphic Most BASs can present data on a floor plan or equipment graphic.	Floor plan with zone temperatures; system graphic with performance data from trendlogs only that may be accessed from a link on the equipment graphic.	Add performance data to the equipment graphic.	Level 2 graphics would meet the requirements for Level 3. Additional graphics to meet Level 3 would be provided by the third-party software tools required for the project.
Data Tables Most BASs can present real-time data in tabular form.	Building air handler summary table as described in Figure 5.3.2.	Expand building air handler summary table, add floor zone table, expand metrics results table to include additional metrics such as energy targets.	Expand metric results table to include additional metrics such as the performance of specific pieces of equipment or the demand response sequence (e.g., starting a generator or increases in space temperature setpoints).
Trendlogs System performance trendlogs over a time series that is specified by the BAS designer.	Collect the following trendlogs (instantaneous, average over the interval, maximum during the interval, minimum during the interval) with a common time interval (e.g., from 1 to 30 min): • Chilled-water-plant delta-T • Chilled-water-plant tons • Outdoor air temperature (dry-bulb temperature) • Outdoor air wet-bulb temperature • Outdoor-air-temperature fraction • Outdoor-air-damper fraction • Meter data (gas, water, electricity, steam, chilled-water flow, etc.)	Add equipment performance plots and third-party software to create these plots	Add system and equipment diagnostic plots as well as software to permit interoperable responses to these events.
X-Y Group Trend Plots This functionality is normally not part of a standard BAS software package. The BAS designer may require BAS trendlog data to be exported in a format that can be consumed by software to be provided by the BAS supplier via a subcontract or from a third party. Alternatively, the BAS designer can require X-Y plots to be built using a spreadsheet tool such as Microsoft Excel.	Not available at this level.	Add X-Y plots (X-Y plots plot data from one trendlog against another trendlog collected at Level 1): • Chilled-water-plant delta-T and chilled-water-plant tons vs. outdoor air temperature • Chilled-water-plant power vs. chilled-water-plant tons • Chilled-water-plant kilowatts per ton vs. outdoor air temperature, outdoor air wet-bulb temperature, and chilled-water-plant tons • HVAC power vs. outdoor air temperature, outdoor air wet-bulb temperature, and chilled-water-plant tons • Total gas flow vs. outdoor air temperature • Outdoor-air-temperature fraction vs. outdoor-air-damper fraction • Whole-building electric energy-use intensity, whole-building HVAC electric energy-use intensity, whole-building natural-gas energy-use intensity, and whole-building water-use intensity vs. average daily outdoor air temperature	Add X-Y plot diagnostics: • Average daily chilled-water supply temperature, daily chilled-water-plant efficiency, and daily total chilled-water-plant electricity use vs. average daily outdoor air temperature, when at least one chilled-water pump is running • Average daily boiler efficiency, daily total boiler-heating-system thermal output, daily total HVAC gas use, and daily total HVAC gas energy vs. average daily outdoor air temperature, when at least one hot-water pump is running • Daily total air-handler volume, average daily air-handler efficiency, and daily total air-handler electricity use vs. average daily outdoor air temperature, when at least one air handler is running Average daily building power vs. average daily outdoor air temperature • Daily HVAC energy-use intensity vs. average daily outdoor air temperature

TABLE E5 BAS Requirements for Performance Monitoring Levels 1, 2, and 3 *(Continued)*

Requirement	Level 1: Data Collection and Trending	Level 2: Level 1 plus Trendlog Data Analysis	Level 3: Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response
X-Y Group Trend Plots (Continued) This functionality is normally not part of a standard BAS software package. The BAS designer may require BAS trendlog data to be exported in a format that can be consumed by software to be provided by the BAS supplier via a subcontract or from a third party. Alternatively, the BAS designer can require X-Y plots to be built using a spreadsheet tool such as Microsoft Excel.	Not available at this level. (Continued)	Add X-Y plots (X-Y plots plot data from one trendlog against another trendlog collected at Level 1) (Continued): • Whole-building electric energy-use intensity, whole-building HVAC electric energy-use intensity, whole-building natural-gas energy-use intensity, and whole-building water-use intensity vs. average daily outdoor air temperature • Chiller kilowatts per ton vs. condenser entering-water temperature and chiller tons • Chiller power vs. chiller tons • Whole-building HVAC electric energy-use intensity, total boiler gas energy-use intensity, whole-building lighting energy-use intensity, and whole-building plug energy-use intensity vs. average daily outdoor air temperature	Add X-Y plot diagnostics (Continued): • Average building air-handler variable-frequency-drive frequency and average building duct static pressure vs. outdoor air temperature
Points (Objects)			

Measured
The BAS designer needs to include these points (objects) in the project Point List Schedule.
	• Outdoor air temperature
	• Outdoor air wet-bulb temperature
	• Main power
	• Main natural-gas flow
	• Main water flow
	• Chiller power
	• Other chilled-water-plant equipment power
	• Plant chilled-water supply temperature
	• Plant chilled-water return temperature
	• Plant chilled-water flow rate
	• Air-handler mixed air temperature, return air temperature, and supply air temperature
	• Air-handler supply-fan and return-fan power
	• Air-handler flow rate
	• Zone temperatures; air-handler duct static pressure; supply air hot duct static pressure, if dual duct
	• Terminal unit supply-air flow, supply air temperature; if dual duct, supply air heating-duct flow and supply air heating-duct temperature
	• Lighting-circuit power
	• Plug-circuit power
	• Rooftop-unit power
	• Other HVAC-equipment power
	• Chiller chilled-water supply temperature
	• Chiller chilled-water return temperature
	• Chiller chilled-water flow rate
	• Boiler gas flow
	• Boiler hot-water supply temperature
	• Boiler hot-water return temperature
	• Boiler hot-water flow rate
	• Air-handler supply-fan variable-frequency-drive frequency
	• Plant condenser-water supply temperature
		Add:
		• Information from devices such as chillers that can only be obtained by making a network connection to the chiller control panel:
		  • Chiller bearing temperature
		  • Chiller effective setpoint (this is the value that the chiller is using based on a setpoint signal from the BAS)
		  • Boiler carbon monoxide (CO) percentage
		  • Boiler stack gas temperature
		  • Internal equipment faults
			It is assumed that all data needed for diagnostic or event triggers is available at Level 1 or Level 2.

TABLE E5 BAS Requirements for Performance Monitoring Levels 1, 2, and 3 *(Continued)*

Requirement	Level 1: Data Collection and Trending	Level 2: Level 1 plus Trendlog Data Analysis	Level 3: Levels 1 and 2 plus Equipment Fault Diagnosis and Event Response
Measured (Continued) The BAS designer needs to include these points (objects) in the project Point List Schedule.	(Continued) • Plant condenser-water return temperature • Plant condenser-water flow rate • Rooftop-unit gas flow rate • HVAC-heater gas flow rate	(See previous page.)	(See previous page.)
Virtual These are software points (objects) that are listed in the Point List Schedule or are determined by the BAS contractor from the sequence of operations.	• Air-handler outdoor-air-damper percentage • Return-damper percentage • Supply-fan mode (per *Sequences of Operation for Common HVAC Systems*[X6]) • Supply-fan status • Chilled-water-valve percentage • Supply air temperature setpoint • Supply air hot deck temperature, supply air hot deck temperature setpoint, hot-water valve position, if dual duct	• Chiller chilled-water supply temperature setpoint • Air-handler duct static pressure setpoint, variable-frequency-drive speed setpoint, and supply air hot duct static pressure setpoint, if dual duct • Terminal unit cooling temperature setpoint, heating temperature setpoint, cooling control signal, and heating control signal	—
Calculated—Whole Building	• Average daily outdoor air temperature • Whole-building peak power • Whole-building electric energy-use intensity • Whole-building natural gas energy-use intensity • Whole-building water-use intensity	Add: • Average building static pressure • Total HVAC electric power • Whole-building lighting power • Whole-building plug power • Whole-building HVAC electric energy-use intensity • Whole-building lighting energy-use intensity • Whole-building plug energy-use intensity	Add: • Average daily outdoor air temperature, when at least one chilled-water pump is running • Average daily outdoor air temperature, when at least one hot-water pump is running • Average daily outdoor air temperature, when at least one air handler is running • Average daily building power; total HVAC electric demand; whole-building HVAC energy-use intensity
Calculated—Chilled Water	• Chilled-water-plant delta-T • Chilled-water-plant power • Chilled-water-loop tons • Total chilled-water-plant tons • Chilled-water-plant efficiency	Add: • Chiller tons • Chiller efficiency • Total chiller power • Total chilled-water-plant heat rejection • Chilled-water-plant heat balance	Add: • Average daily chilled-water supply temperature • Daily total chilled-water-plant electricity use • Daily chilled-water-plant energy • Maximum daily chilled-water-plant energy • Average daily chilled-water-plant efficiency
Calculated—Natural Gas Equipment	—	Add: • Total boiler gas flow • Total boiler gas energy-use intensity • Boiler output • Boiler efficiency • Total boiler output • Total boiler efficiency	Add: • Total roof top unit gas flow rate • Total HVAC gas flow rate • Daily total HVAC natural gas use • Daily total HVAC natural gas energy • Maximum daily HVAC natural gas energy • Total HVAC natural gas energy-use intensity • Average daily boiler efficiency
Calculated —Supply Air	• Air-handler outdoor-air-temperature fraction • Air-handler outdoor-air-damper fraction • Total air-handler power • Total air-handler volume • Air-handler specific power	Add: • Instantaneous average building air-handler supply fan variable-frequency-drive frequency	Add: • Daily total air-handler electricity use • Daily total air-handler volume • Maximum daily air-handler volume • Average daily air-handler specific power
Event Response Initiation	None	None	Initiate a runtime report or a demand response request based on a real-time pricing signal.

PART 1 - GENERAL

1.1 Product Data

.1 Submit product data and accordance with Mechanical General Provisions 15010.

1.2 Maintenance Data

.1 Provide maintenance data for incorporation into maintenance manual specified in Mechanical General Requirements 21 05 01.

PART 2 - PRODUCTS

2.1 Expansion Compensators

.1 Slip Type:

.1 For axial pipe movement: complete with packing chamber, limit stops, lubrication fittings or lubricant impregnated packing rings.

.2 Packing material: as recommended by manufacturer.

.3 Slip pipe: hard chrome plated to ASTM A53-82, carbon steel.

.4 Standard of Acceptance: Flexonics.

.2 Bellows Type:

.1 For axial, lateral or angular movements with stainless steel or neoprene elastomer bellows, guides, control rings, travel stops, flanged.

.2 Standard of Acceptance: Flexonics.

2.2 Flexible Connections

.1 Inner hose: bronze or stainless steel corrugated.

.2 Braided wire mesh bronze or stainless steel outer jacket.

.3 Size and end connection as required.

.4 Complete unit suitable for working pressure of 1034 kPa and working temperature of 93 deg. C.

.5 Connector length shall be as per manufacturer’s recommended length for continuous vibration.

.6 Standard of Acceptance: Senior Flexonics.

PART 3 - EXECUTION

3.1 Installation

.1 Install expansion compensators as required to prevent thermally inducted pipe motion and/or excessive reaction forces.

.2 Install in accordance with the manufacturer's instructions.

END OF SECTION

PART 1 - GENERAL

1.1 Shop Drawings

.1 Submit shop drawings in accordance with Mechanical General Requirements section 21 05 01.

.2 All vibration and noise control products shall be supplied by one manufacturer.

PART 2 - EXECUTION

2.1 Spring Mount

.1 Zinc or cadmium plated hardware; housings coated with rust resistant paint colour coded with leveling adjustments.

.2 Stable open spring with equal stiffness in the horizontal and vertical planes. Support on bonded 10mm minimum thick ribbed neoprene vibropad to absorb sound.

.3 Standard of Acceptance: Vibro-Acoustics, Model FS.

2.2 Spring Hangers

.1 Colour coded springs, rust resistant, painted box type hangers.

.2 Stable spring, elastomeric washer.

.3 Standard of Acceptance: Vibro-Acoustics, Model SH or SHR.

2.3 Machinery Mounting Rubber Mat

.1 Neoprene, oil resistant, corrugated mat.

.2 Standard of Acceptance: Vibro-Acoustics, Model R-Pad.

PART 3 - EXECUTION

3.1 Installation

.1 Install vibration isolation for energy recovery unit, centrifugal fans, heat pumps, pipes and all other equipment that produces vibration, all in accordance with equipment manufacturer’s instructions. Adjust mountings to level equipment.

.2 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping and ducting passage through walls and floors do not transmit vibrations.

.3 Unless indicated otherwise, support piping in Mechanical room connected to isolated equipment with spring mounts or spring hangers with 25mm minimum static deflection as follows:

.1 For pipe sizes up to 100mm: first 3 points of support.

.2 First point of support shall have a static deflection of twice deflection of isolated equipment, but not dflect more than 50mm.

.4 Piping shall be connected to isolated equipment such as circulating pumps by flexible connections.

.5 Block and shim level all bases so that ductwork and piping connections can be made to a rigid system at the operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.

3.2 Site Visit

.1 Arrange for manufacturer's representative to visit site to ensure installation is in accordance with manufacturer's instructions and make adjustments and corrections in accordance with written report.

.2 Provide Consultant with notice 24 hours in advance of manufacturer's representative's visit.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Provide thermal insulation in conformance with the Ontario Building Code Supplementary Standard SB-10.

.2 Fire resistance.

.1 Meet NFPA 90A-1981. Maximum flame spread rating of 25 and maximum smoke developed rating of 50 in accordance with ASTM E84-81a, NFPA 255-1979 and CAN4-S102-M80.

.2 Materials which have been approved for special applications by those authorities having jurisdiction are acceptable.

.3 Materials tested in accordance with ASTM C411-82 shall not flame, smolder, glow or smoke at temperature to which exposed in service.

1.2 Definitions

.1 "CONCEALED" - insulated mechanical services and equipment in trenches, chases, furred spaces, pipe shafts or hung ceilings.

.2 "EXPOSED" - will mean "not concealed" as defined herein.

PART 2 - PRODUCTS

2.1 Rigid Fibreglass with Vapour Barrier

.1 Application: insulating system for rectangular ducting as follows:

.1 All supply air ductwork from heat recovery unit to all heat pumps.

.2 All supply air ducts except exposed ducts from heat pumps.

.3 Return air ductwork as noted on drawings.

.2 Material:

.1 CGSB 51-GP-10M, rigid mineral fiber board for ducting and CGSB 51-GP-52M vapour barrier jacket and facing material.

.2 Acceptable Products: Fiberglass Canada Inc. - Vapour-Seal Duct Insulation; AF530 for general areas and AF545 for exposed ductwork and all ductwork in Mechanical Rooms.

2.1 Rigid Fibreglass with Vapour Barrier (Cont.).

.4 Thickness:

Insulation Thickness Nominal	Operating Temperature
25mm	0 deg to 65 deg C.
100mm or 2 - 50mm layers (ductwork exposed to weather)	-40 deg to 0 deg C.

100mm for intakes and exhaust ductwork for 5m from exterior walls.

2.2 Fastenings

.1 Tape: self adhesive, 100mm wide rated under 25 for flame spread and under 50 for smoke development.

.2 Contact adhesive: quick-setting, non-flammable fire resistive adhesive to adhere fibrous glass to ducts. Flame spread 15 smoke development 0.

.1 Acceptable Products: Foster 85-20; Armstrong 520.

.3 Pins:

.1 Weld pins 4mm diameter, with 35mm diameter head for installation through the insulation. Length to suit thickness of insulation.

.2 Weld pins: if duct is over 635mm wide, use on bottom of duct.

.3 Acceptable Products: Duro Dyne, Clip-Pin.

.4 Weld pins 2.0mm for installation prior to applying insulation. Length to suit thickness of insulation. Nylon retain clips 32mm square.

.5 Acceptable Products: Duro Dyne spotter pins with spotter clips or stop clips as required.

PART 3 - EXECUTION

3.1 Application

.1 Apply insulation after required tests have been completed and approved by Engineer. Insulation and surfaces shall be clean and dry when installed and during application of any finish.

.2 Work shall be performed by insulation journeyman.

.3 Install insulation with smooth and even surfaces.

.4 Apply insulation materials accessories and finishes to manufacturer's recommendations.

3.2 Duct Insulation

.1 General:

.1 Stagger longitudinal and horizontal joints, on multi-layered insulation.

.2 Mechanical Fasteners:

.1 On rectangular ducts, use 50% coverage of insulating cement and weld pins at not more than 200mm centres, but not less than 2 rows per side.

3.3 Weatherproofing

.1 General:

.1 Weatherproof all insulated exposed ductwork.

.2 Apply two 3.2mm (1/8") thick coats of asphalt or vinyl mastic with glass reinforcing fabric between coats, lapping joints a minimum of 51mm (2"). Cover with aluminum jackets, banded on 305mm (12") centers with 12mm x 0.40mm (1/2" x 0.015") aluminum bands.

.3 Weather-seal all joints.

END OF SECTION

PART 1 - GENERAL

1.0 GENERAL REQUIREMENTS

1.1 Conform to section 21 05 01 “Mechanical General Requirements”.

1.2 All work shall conform to the City of Toronto ‘Standard Building Automation System (BAS) Specification’, September 2017 edition (Copy attached in Spec Volume 3 for reference).

1.3 Refer to schedules on the project drawings for work relating to the BAS system. Note that all pumps are specified with integral Variable Frequency Drives (see pump schedule on drawing M-18)

1.4 Building occupied hours are expected to be between 6am and 8pm.

1.5 The BAS contractor shall provide all valves, actuators, damper motors, temperature/pressure sensors indicated on the mechanical drawings and herein.

PART 2 – PRODUCTS

1.0 Refer to City of Toronto ‘Standard Building Automation System (BAS) specifications for hardware and software requirements.

PART 3 – SEQUENCE OF OPERATION

.1 Heat Pumps (Water-to-Water)

.1 The temperature sensor for mass tank T-1 shall stage on or off heat pumps WHP-1, WHP-2 ,WHP-3, WHP-4 and WHP-5 cycle pump P-5 to maintain 52^{o} C (125^{o}F). tank temperature set point. Pump P-5 is equipped with an integral Variable Frequency Drive driven by pressure feedback from Heat Pump supply valve position.

.2 Each heat pump represents a stage. Each heat pump will change number after every sequence. Heat pump number 1 will become number 2, 2 goes to 1 and so on, so that a different heat pump is lead until the last unit becomes number 1.

.3 No heat pump shall operate before proof of flow of geothermal fluid as well as load fluid, by means of flow switch.

.4 Each heat pump shall be equipped with a slow closing motorized valve on the Heat pump supply line (HPS) and one on the Heating water return from mass tank T-1. These valves shall shut fluid flow when the compressor is not running. Valve opening and closing time shall be 5 seconds or less.

.2 Domestic Hot Water System

.1 The temperature sensors (T-16 and T 17) on domestic preheat tanks DWH-1 and DWH-2 shall modulate motorized valves to maintain 46^{o} C (115^{o} F). tank temperature set point.

.2 Recirculation pump P-8 shall operate continuously during occupied hours.

.3 Electric Booster tank DWH-3 shall be enabled to enabled to maintain 60° C (140°F)

.3 Failsafe Conditions

.1 In the event that either P-1, P-2, P-3 or P-4 fails, the control system shall switch operation to the companion pump.

.2 System flow for pump failure indication shall be by pressure sensors located on the supply and return headers and an electronic pressure differential controller.

.3 **All pumps** shall be restarted automatically after power failures.

.4 Provide phase loss relays on each pump. Upon phase loss detection the control system shall go into sequential shutdown of the entire HVAC system and provide alarm at the operator's terminal.

.4 Geothermal Circuit Circulation System

.1 Pumps P-3 & P-4 serving the geothermal circuit will operate as lead/lag with a timed alternating cycle to ensure even wear. In the event of a failure of the lead pump, the pumps controls shall engage the lag pump. Each pump is controlled through an integrated sensorless variable frequency drive embedded with control software provided by pump supplier, in addition, the BAS system shall control flow to maintain a minimum temperature of 4.4°C (40°F) read from temperature sensor T-2.

.2 The BAS system shall monitor pressure, temperature and flow rate (frequency).

.5 Heat Pump Circuit Circulation System

.1 Pumps P-1 & P-2 serving the heat pump circuit will operate as lead/lag with a timed alternating cycle to ensure even wear. In the event of a failure of the lead pump, the pumps controls shall engage the lag pump. Each pump is controlled through an integrated sensorless variable frequency drive embedded with control software provided by pump supplier.

.2 The BAS system shall monitor pressure, temperature and flow rate (frequency).

.6 Heat Pumps (Water-to-Air)

.1 Provide space temperature sensors at locations shown on the drawings.

.2 Space sensors shall be tamper-proof.

.3 Sensor initially set maintain 22° C (72° F) Day and 16° C (60° F) Night temperatures, heating cycle; 24° C (75° F) Day and 27° C (80° F) night, cooling cycle.

.4 Provide duct mounted discharge temperature sensors at each heat pump these will be used for maintenance and diagnostics.

.5 Provide slow closing motorized valves on the fluid supply interlocked with the compressor start circuit to shut fluid flow when compressor is inactive.

.7 Heating Water Loop

.1 Pump P-6 equipped with integral VFD shall modulate based on pressure feedback from system modulating valves.
.2 The BAS system shall monitor pressure, temperature and flow rate (frequency).

.8 Force Flow Heaters

.1 Ceiling or Wall Mount

.1 Install in the space at the location shown a temperature sensor. The BAS system shall control temperature and activate the unit fan.

.2 Provide tamper-proof Sensor.

.3 Set sensors to maintain 21° C (70° F).

.9 Panel Heaters

.1 These are self-controlled by a thermostatic radiator valve supplied by Panel manufacturer.

.2 Initial set point 20° C (68° F).

.10 Heat Recovery Unit (HRU-1)

.1 Provide a discharge air temperature sensor, set at 21° C. (70° F.) – adjustable – located downstream of heating coil shall activate and modulate the motorized valve on heating coil HC-1 to maintain setpoint temperature.

.2 The unit comes complete with internal controls (BacNet Compatible) the BAS system shall monitor all unit functions, Fans shall be controlled by the BAS system in the power outage mode.

.3 Also refer to the specifications of water to water heat pumps (Section 23 81 40 for heating and cooling operation mode and HRU for the unit's integral controls (Section 23 74 33).

.4 HRU air flow set points are provided on M-13.

.11 System Leakage Alarm

.1 The BAS system shall monitor the following fluid make-up systems:

.1 The ground exchanger make-up system (55l)
.2 The PVT circulation system (55l)
.3 Coil HC-1 circulation system

.2 Each system has an integral control panel with alarms, the BAS system shall monitor the alarms and display at the operator's terminal.

.12 <u>Sump Pumps</u>

.1 The BAS system shall monitor alarms and display at the operator's terminal.

.13 <u>Power Outage Mode (Resiliency Mode)</u>

.1 During a power outage the following systems shall be powered by a Tesla 'Power Wall' storage battery system. Provide all necessary control devices and software to keep the following systems operational **<u>only</u>** on the ground and second floors:

- Heat Recovery Unit HRU-1 fans shall be run at 50% capacity
- Fire alarm (entire system)
- Communications including Safe Area communication panels
- Entry access systems
- Security systems
- BAS system
- All points indicated on panel schedules SB and SB1 on electrical drawing E-12.

.2 Flow of ventilation air and exhaust to the basement area shall be shut down by closing motorized dampers MD-1 to MD-5.

.14 Demand Ventilation Air Control

.1 The ventilation air supply to each heat pump shall be controlled by motorized dampers activated by CO_2 sensors located within the zones served by each of the heat pumps.

.2 Provide CO_2 sensors, wiring, and damper motors to serve each damper, refer also to damper schedule shown on mechanical Drawing M-18. The HRU shall be shut down during unoccupied hours.

.15 PVT Thermal Control

.1 The system consists of pumps P9 (building circuit), P-10 (panel pump) and heat exchanger HE-2. See DWG. M-14 for schematic.
Provide a temperature sensor (T4A) at the piping connection to one of the centrally located PVT panels to be chosen by the Engineer.
Units. Pumps P-9 and P-10 shall not operate under the following conditions:

- PVT sensor T4A senses a temperature less than 27^{o}C (80^{o}F) (initial setting)
- Between the hours of 6pm and 9am.
- The geothermal loop temperature exceeds 38^{o}C (100^{o}F).

`.16 Lighting Control

.1 Provide lighting control for interior and exterior lighting.

.2 Exterior lighting shall be controlled via photocell and time of day refer to E-11 for relays.
.3 Interior lighting at perimeter windows shall be photocell controlled with manual override.
.4 Interior lighting other than perimeter lighting shall be controlled by combination motion sensors and dimmer with manual override as indicated on the electrical drawings. Refer to electrical drawings for lighting control and switching locations.

.17 Data Acquisition Points

.1 Provide metering equipment to measure thermal energy and electrical energy.

.2 The BAS system shall record and log the following information:

.1 Total and Net electrical energy used hourly
.2 Hourly temperature data, outdoor and indoor temperature, geothermal fluid Temperature, PVT supply temperature,
.3 Thermal energy flow from the geothermal heat exchanger and the PVT thermal system.

.18 <u>Point Schedule</u>

.1 It is this Section's responsibility to check requirements based upon system descriptions and general commentary and sequence of operation and provide a complete points schedule for review.

"WATER-TO-AIR HEAT PUMPS"

BUILDING AUTOMATION SYSTEM

				ANALOG INPUTS				DIGITAL INPUTS				CONTROL				
POINT DESCRIPTION	**COLOR GRAPHICS**	**INSTRUMENT CODE**	**RUN TIME**	**HIGH ALARM**	**LOW ALARM**	**VALUE**		**STATUS**	**ALARM**	**OVERRIDE**		**ANALOG**	**STOP/ START**	**OPEN/ CLOSE**		SPECIAL FUNCTION
SPACE TEMPERATURE				X	X	X										
FAN													X			
COMPRESSOR								X					X			
REVERSING VALUE														X		
NIGHT S.B.										X						
DISCHARGE TEMP					X				X							
DRAIN PAN OVERFLOW SWITCH									X							
FLUID FLOW SHUT OFF VALVE													X			

"INTERNAL HEAT PUMP LOOP"

BUILDING AUTOMATION SYSTEM

			ANALOG INPUTS					DIGITAL INPUTS					CONTROL					
POINT DESCRIPTION	**COLOR GRAPHICS**	**INSTRUMENT CODE**	**RUN TIME**	**HIGH ALARM**	**LOW ALARM**	**VALUE**		**STATUS**	**ALARM**	**OVERRIDE**	**DRIVE FREQUENCY VALUE**	**SPEED ADJUST**		**ANALOG**	**STOP/START**	**OPEN/CLOSE**		SPECIAL **FUNCTION**
LOOP RETURN TEMPERATURE				X	X	X												
LOOP SUPPLY TEMPERATURE				X	X	X												
PUMPS P-1 AND P-2			X					X							X			
GLYCOL FEED TANK									X									
VFD											X	X						

"GEOTHERMAL LOOP"

BUILDING AUTOMATION SYSTEM

	ANALOG INPUTS							DIGITAL INPUTS				CONTROL					
POINT DESCRIPTION	COLOR GRAPHICS	INSTRUMENT CODE	RUN TIME	HIGH ALARM	LOW ALARM	VALUE		STATUS	ALARM	OVERRIDE	DRIVE FREQUENCY VALUE	SPEED ADJUST	ANALOG	STOP/START	OPEN/CLOSE		SPECIAL FUNCTION
LOOP RETURN TEMPERATURE				X	X	X											
LOOP SUPPLY TEMPERATURE				X	X	X											
PUMPS P-2 AND P-3			X					X						X			
GLYCOL FEED TANK									X								LEAK ALARM
VFD											X	X					

"WATER-TO-WATER HEAT PUMPS"

BUILDING AUTOMATION SYSTEM

					ANALOG INPUTS			DIGITAL INPUTS				CONTROL				
POINT DESCRIPTION	COLOR GRAPHICS	INSTRUMENT CODE	RUN TIME	HIGH ALARM	LOW ALARM	VALUE		STATUS	ALARM	OVERRIDE		ANALOG	STOP/START/MODULATE	OPEN/CLOSE		SPECIAL FUNCTION
MASS TANK TEMPERATURE T-9					X	X										
FLUID FLOW SHUT OFF VALVE													X			
COMPRESSOR								X					X			
REVERSING VALVE						X								X		
SUPPLY/RETURN TEMP TO MASS TANK T-10 AND T-11					X	X										
PUMP P-5													X			
FLOW CONTROL VALVES (10)														X		INTERLOCK WITH UNIT COMPRESSORS

"HEAT RECOVERY UNIT"

BUILDING AUTOMATION SYSTEM

	ANALOG INPUTS							DIGITAL INPUTS						CONTROL				
POINT DESCRIPTION	COLOR GRAPHICS	INSTRUMENT CODE	RUN TIME	HIGH ALARM	LOW ALARM	VALUE		STATUS	ALARM	OVERRIDE	DRIVE FREQUENCY VALUE	SPEED ADJUST		ANALOG	STOP / START	OPEN / CLOSE / MODULATE		SPECIAL FUNCTION
HEATING								X						X				
HRU EXHAUST TEMP.						X												
HRU RETURN AIR TEMP.						X												HEATING & COOLING RESET CONTROL
HRU SUPPLY AIR TEMP.						X								X				
HRU SUPPLY FAN								X							X			
HRU RETURN FAN								X							X			
LOW LIMIT								X										
DIRTY FILTER								X										PROVIDE PRESSURE DIFF. SWITCH
LEAVING AIR TEMP AFTER HEAT RECOVERY						X												
HC-1 ENTERING AIR TEMP.						X												
HC-1 LEAVING AIRTEMP.						X												
RETURN AIR HUMIDITY						X												HUMIDITY RESET CONTROL
HC-1 CONTROL VALVE						X								X				
P-7									X		X	X			X	X		
HE-1 MOD VALVE						X								X	X	X		
GLYCOL FEED TANK									X									LEAK ALARM
ZONE SUPPLY AND RETURN AIR DAMPERS																X		SEE MECHANICAL DWGS FOR SCHEDULE. PROVIDE CO_2 SENSORS FOR EACH ZONE

"TYPICAL DOMESTIC HOT WATER SYSTEM"

BUILDING AUTOMATION SYSTEM

	ANALOG INPUTS							DIGITAL INPUTS					CONTROL			
POINT DESCRIPTION	COLOR GRAPHICS	IN TRUMENT CODE	RUN TIME	HIGH ALARM	LOW ALARM	VALUE		STATUS	ALARM	OVERRIDE		ANALOG	STOP/START	OPEN/CLOSE/MODULATE		SPECIAL FUNCTION
DOMESTIC HOT WATER REHEAT TANK DWH-3													X			
RECIRCULATION PUMP P-8													X			
SUPPLY WATER TEMPERATURE					X	X										
DOMESTIC HOT WATER PREHEAT TANKS DWH-1 & DWH-2 HEAT EXCHANGER MOTORIZED VALVES														X		
TEMPERATURE SENSORS T-16, T-17 AND T-18						X										

"TYPICAL EXTERIOR /INTERIOR ZONE LIGHTING CONTROL"

BUILDING AUTOMATION SYSTEM

	ANALOG INPUTS							DIGITAL INPUTS				CONTROL				
POINT DESCRIPTION	**COLOR GRAPHICS**	**IN TRUMENT CODE**	**RUN TIME**	**HIGH ALARM**	**LOW ALARM**	**VALUE**		**STATUS**	**ALARM**	**OVERRIDE**		**ANALOG**	**STOP/ TART**	**OPEN/ CLOSE**		SPECIAL **FUNCTION**
ZONE LIGHTING RELAYS													X			PROVIDE PHOTOCELL CONTROL TO TURN LIGHTS ON AT DUSK OFF DAWN
PARKING (INCLUDES BUILDING FLOODLIGHTS													X			COORDINATE WITH ELECTRICAL DRAWINGS
INTERIOR LIGHT CONTROL													X			PROVIDE POINTS AS FOLLOWS: BASEMENT: 4POINTS FIRST FLOOR : 7POINTS SECOND FLOOR: 7POINTS

" PVT THERMAL CONTROL "

BUILDING AUTOMATION SYSTEM

				ANALOG INPUTS				DIGITAL INPUTS				CONTROL				
POINT DESCRIPTION	**COLOR GRAPHICS**	**INSTRUMENT CODE**	**RUN TIME**	**HIGH ALARM**	**LOW ALARM**	**VALUE**		**STATUS**	**ALARM**	**OVERRIDE**		**ANALOG**	**STOP/START**	**OPEN/CLOSE**		SPECIAL FUNCTION
GLYCOL FEED TANK									X							LEAK ALARM
PUMPS P-9 AND P-10													X			
PVT TEMP T4A						X		X								
SUPPLY AND RETURN TEMP T4 AND T-5						X										

"TYPICAL ELEVATOR CONTROL ROOM"

BUILDING AUTOMATION SYSTEM

		ANALOG INPUTS						DIGITAL INPUTS				CONTROL				
POINT DESCRIPTION	**COLOR GRAPHICS**	**INSTRUMENT CODE**	**RUN TIME**	**HIGH ALARM**	**LOW ALARM**	**VALUE**		**STATUS**	**ALARM**	**OVERRIDE**		**ANALOG**	**STOP/ START**	**OPEN/ CLOSE**		SPECIAL FUNCTION
TEMPERATURE SENSOR						X			X							
EXHAUST FAN			X										X			

"MISCELLANEOUS POINTS"

BUILDING AUTOMATION SYSTEM

	ANALOG INPUTS							DIGITAL INPUTS				CONTROL				
POINT DESCRIPTION	**COLOR GRAPHICS**	**INSTRUMENT CODE**	**RUN TIME**	**HIGH ALARM**	**LOW ALARM**	**VALUE**		**STATUS**	**ALARM**	**OVERRIDE**		**ANALOG**	**STOP/ START/ MODULATE**	**OPEN/ CLOSE**		SPECIAL **FUNCTION**
FIRE ALARM PANEL									X							EMS TO PROVIDE A RECORD OF FIRE ALARM PANEL. TROUBLE SIGNAL AND TIME OF OCCURRENCE
TYPICAL OUTDOOR AIR TEMPERATURE						X										MUST BE RTD
SUMP PUMPS									X							HIGH WATER ALARM
CIRCULATING PUMPS								X					X			
SECURITY SYSTEM								X								MONITOR AND LOG ALARMS
DATA GATHERING POINTS																PROVIDE 10 POINTS FOR DATA COLLECTION SYSTEM
FORCE FLOW HEATER SUPPLY VALVES						X							X			MODULATE VALVES BASED ON TEMP SENSOR IN SPACE.
FORCE FLOW HEATER FANS													X			
FORCE FLOW HEATER RETURN AIR TEMPERATURE					X	X										

END OF SECTION

PART 1 - GENERAL

1.1 GENERAL

1.1.1 Division 23 shall be responsible to carry out all the Work set out or referred to in this Section.

1.2 DESCRIPTION OF WORK

1.2.1 Supply, install and commission Thermal Energy/BTU Meters and associated flow sensors and two temperature sensors, thermal wells and the energy computer including all pipe, by pass valve and two isolation vales for each BTU/Thermal Energy Meters including all necessary pipe fittings, wiring and interconnects/ fasteners for the facility as shown in the mechanical drawings required for meeting M&V requirement. The Thermal Energy/BTU Meters shall be capable of integrating into the central data logger (i.e., the DMS and/or the Building Automation System).

1.3 SUBMITTALS

1.3.1 Submit dimensioned shop drawings and manufacturer's product data sheets for all equipment and associated hardware specified in this section including but not limited to meter enclosure, encoder and data output modules as applicable.

1.3.2 Shop drawings must be submitted for approval. Any deficiencies in the shop drawings must be resolved to achieve the Metering and Monitoring strategy requirement.

1.3.3 Do not supply any equipment to this project prior to shop drawing review by the consultant. Shop drawings shall be stamped and signed by the contractor prior to submittal.

1.3.4 After shop drawing review, the approved drawings (i.e., stamped by Mechanical designer) will be issued to the Electrical and Mechanical Contractor for installation.

PART 2 – PRODUCTS

2.1 MATERIALS

2.1.1 Thermal Energy/BTU meters shall be a "True" energy meters capable of measuring flow rates from flow sensors as well as measuring supply and return temperatures from the two temperature sensors and computing energy consumption using the field level energy computer. The Thermal Energy/BTU meter shall be compatible to be interconnected to the Digital Metering System or the Building Automation System and also acceptable and approved by Governmental Authorities as applicable and the Digital Metering System or Building Automation System supplier.

2.1.2 BTU/Thermal Energy Meters size, location and quantities shall be shown on relevant mechanical drawings.

2.1.3 The BTU/Thermal Energy Meter(s):

2.1.3.1 Shall be supplied by Division 23, Division 22 and Division 20 (Mechanical/Plumbing) contractors.

2.1.3.2 Shall be in-line flanged type and/or ultrasonic clamp-on type devices as per the Mechanical Designers specification.

2.1.3.3 Each energy meter including temperature sensors, flow meter and energy computer shall be factory programmed and calibrated for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required as an on-going basis).

2.1.3.4 Shall be suitable for flow rate, pressure and temperature, and pipe size required as specified in the Mechanical Drawings

2.1.3.5 Flow sensor accuracy ± 0.2% of reading between 1.6 ft/s through 33 ft/s. for Magnetic Flow Meter. Flow sensor accuracy ± 1.0% of reading between 1.0 ft/s through 40 ft/s., for ultrasonic clamp-on type Flow Meter. The velocity range shall be bi-directional. The Operable flow range shall be 1000:1.

2.1.3.6 The calculated differential temperature used in the energy calculation shall be accurate to within ± 0.15°F (including the error from individual temperature sensors, sensor matching, input offsets, and calculations)

2.1.3.7 The Energy Calculator will collect relevant flow and temperature readings and calculate energy based on required data. The Energy calculator will be equipped with suitable signal output to provide totalized energy consumption, volume flow rate, both supply and return fluid temperatures which are capable of integration into the Building Automation System network.

2.1.3.8 The Energy calculator, flow element will be equipped with integral LCD display as a visual read-out panel at the field level.

2.1.3.9 The flow sensor flanges shall have a pressure rating of ASME class 150 and Class 300 as approved by Mechanical Designer for various location.

2.1.3.10 Shall have a fluid temperature rating of -40° C to+180° C or as approved by Mechanical Designer. Ambient temperature range -18° C to 65° C or as approved by Mechanical Designer.

2.1.3.11 The temperature sensors for supply and return fluid shall:

2.1.3.11.1 Be matched pairs.

2.1.3.11.2 Have RTD sensors installed in hot tapped stainless steel thermowells complete with heat conductive compound.

2.1.3.11.3 Have thermowells sized to ensure that the wells measure the flow midstream

2.1.3.11.4 Have Temperature sensor accuracy will be 0.1% of full-scale value.

2.1.3.12 All circuits for inputs, outputs, and power supply will be galvanically isolated from each other.

PART 3 – EXECUTION

3.1 INSTALLATION

3.1.1 Install BTU/Thermal Energy meter and associated devises in accordance with BTU/Thermal Energy meter manufacturer's instructions and to the satisfaction of the Governmental Authority, complete with two isolation valves and a valved by-pass and bleed-off valve. All valves, flanges, pipe, joints, fitting and piping material shall meet requirements specified in Division 23.

3.1.2 Pre-inspect and measure physical spacing to ensure future safe and easy servicing of BTU/Thermal Energy meter.

3.1.3 Ensure that BTU/Thermal Energy meters are to be installed such that normal flow direction matches flow meter's corresponding flow direction.

3.1.4 Install BTU/Thermal Energy meter and associated devices on correct services (per drawings), ensuring they are properly supported with adequate pipe hangers, pipe support etc., to not put excess strain on supply and return hydronic pipes.

3.1.5 Ensure that BTU/Thermal Energy meters and associated devices are accessible with identification tags visible, serial numbers facing outward, for installation inspection purposes by Operations and Maintenance personnel.

3.1.6 Comply with all requirements identified in Applicable Law.

3.1.7 Data communications cable from BTU/Thermal Energy meter to the Digital Metering System (DMS) or Building Automation System (BAS) supplied and installed by Division 23/22/20. Final connection to the Digital Metering System or Building Automation System shall be completed by Division 26 or Division 23, as applicable.

3.1.8 All wiring will be done in accordance with Canadian National Electric Code standards and regulations, and in conjunction with the local Electrical Safety Association office.

3.1.9 After installation is complete, test system for leaks and test and adjust controls and safeties. Repair leaks and retest until no leaks occur. Replace any damaged or malfunctioning controls and equipment.

3.1.10 Use laminated plastic (Lamacoid) black-white-black with beveled edges, stainless steel screws, and proper identification engraving for identification nameplates for each natural gas meter and associated valves. Each nameplate to be sized to suit equipment for which it is provided, and required wording. Confirm nomenclature with Consultant. Various color configurations to be used to differentiate systems. Confirm exact color scheme with Consultant and/or Owner.

3.1.11 Provide necessary patch-up paints on the hydronic pipeline and associated pipe fittings as per code compliance.

3.1.12 Provide necessary insulation of the meter elements, RTDs and associated pipe fitting, valves, exposed pipeline as per meter manufacturer's recommendation and complete patch up insulation work as required as per Division 23

3.1.13 Neatly secure exposed communication wire in enclosures and meter ends with approved supports or ties.

3.1.14 Provide conduits as sized on drawings for wiring.

3.1.15 Provide necessary wiring as required through conduits as shown in drawings.

3.1.16 Coordinate installation with other trades making connections to equipment, namely control and power connections. Start-up and calibrate equipment as per manufacture's recommendations.

3.2 CALIBRATION AND MAINTENANCE SERVICE

3.2.1 Include for training as recommended by the BTU/Thermal Energy meter manufacturer for safety and operating instructions.

3.2.2 Setup meters according to BTU/Thermal Energy meter manufacturer's instructions.

3.2.3 Commission the Thermal Energy/BTU meter by the meter manufacturer or by their designated representative to the satisfaction of the owner and the M&V Consultant and demonstrate the proper functioning of the metering system. Submit commissioning report and the meter commissioning certificate (If available) to the owner.

3.2.4 Provide shop test calibration certificates of thermal energy meters from the meter manufacturer.

3.2.5 The meter vendor must provide documentation showing that meters have been specified to conform with Canadian Standards Association (CSA) C900 Heat Meter Standards or the European Committee for Standardization (CEN) Standard EN 1434.

3.2.6 Provide commissioning report including records of on-site point-to-point calibration of meters confirming that correct multipliers are used while programming the correct BTU/Thermal Energy meter data on the Digital Metering System or the Building Automation System to read and archive accurate and reliable BTU/Thermal Energy consumption data.

3.2.7 Division 23/22 Contractor will coordinate with Division 26 and/or Division 25 to demonstrate and confirm that the all meter data physically recorded on the field level energy computer itself are the same readings integrated, trend-logged and archived on the Building Automation System with proper time stamp, unit of measurement, correct meter ID, at 15-minute's interval and archived on the historical database for at least 36-months.

3.2.8 All equipment shall be free from defect in materials and workmanship under normal use and service for the period of twelve (12) months from the date of substantial completion.

3.2.9 All equipment will be verified by a factory-trained technician and certified for its design accuracy.

END OF SECTION

1 GENERAL

1.01 SUBMITTALS

.1 **Product Data**: Submit product data sheets for all products specified in this Section. Product data sheets must confirm that the products proposed meet all requirements of the Contract Documents.

1.02 QUALITY CONTROL

.1 To ensure the complete system installed functions as designed, some hydronic speciality shop drawings cannot be reviewed by the Engineer until shop drawings for related equipment impacting the speciality product's performance or selection have also been submitted.

.2 Pressure ratings specified in this section are minimum for all equipment. Provide hydronic specialties suitable for use at design pressures as noted on the drawings or as calculated for the system.

2 PRODUCTS

2.01 PRESSURE RELIEF VALVES

.1 ASME tested, rated, and certified, bronze or cast iron, bronze fitted, 1725 kPa (250 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. Acceptable products are:

.1 ITT Bell & Gossett 3301/4100, or 790/1170

.2 Dresser Industries "CONSOLIDATED"

.3 Spirax Sarco Ltd. SVI Series

.4 McDonnell & Miller Models 250 and 260

.5 Conbraco 10-600 Series

.6 Watts Industries (Canada) Inc. 174A or 740

.7 Victaulic Bermad Series 973-Q

2.02 AIR VENTS

.1 **Manual Air Vents**: Equal to Conbraco 27 Series, 3.2 mm (⅛") diameter with a key handle.

.2 **Automatic Air Vents**: Float actuated air vents, each complete with a semi-steel body and a cap, a stainless-steel float assembly and seat, and a neoprene head. Acceptable products are:

.1 Spirax Sarco Ltd., Type 13 W for system working pressures to 1035 kPa (150 psi), 13 WH for system working pressures greater than 1035 kPa (150 psi).

.2 Armstrong International Inc. No. 1-AV.

2.03 PIPING STRAINERS – "Y" SHAPED

.1 Wye shaped strainers, bronze with sweat type or flanged connections in copper piping, cast iron with screwed, flanged, or grooved end connections in steel piping, minimum 1725 kPa (250 psi) rated and complete with a removable perforated type 304 stainless steel 20 mesh screen, and, for strainers 40 mm (1½") diameter and larger, a blow down pipe connection tapping.

.1 Standard of Acceptance - Grooved end: Victaulic Style 732, W732

2.04 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 1105 kPa (160 psi) at 180° C (350° F) in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.

.2 Acceptable products are:

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

.2 ITT Bell & Gossett "Rolairtrol"

.3 Taco Canada Ltd. "Vortech"

2.05 EXPANSION TANK

.1 Replaceable bladder or vertical head & shell diaphragm type, factory pressurized expansion tank with permanent separation of air and water, as per the drawing schedule and complete with:

.1 A steel pressure tank suitable for the working pressure of the system at 115° C (240° F), constructed and stamped in accordance with the ASME Code for Unfired Pressure Vessels and complete with a system connection, drain connection, air charging valve, and a red oxide primer finish.

.2 A heavy-duty butyl rubber (EDPM) bladder.

.3 A tapping for installation of a pressure gauge.

.4 For horizontal tanks only, mounting saddles supplied loose.

.2 Acceptable products are:

.1 Calefactio Solutions AL Series "Expanflex"

.2 S.A. Armstrong Ltd. Series "Series AX”

.3 ITT Bell & Gossett Series "B" (ASME)

.4 Amtrol "Extrol" “Type L”

2.06 GLYCOL SOLUTION MIXING AND STORAGE TANK

.1 Package type glycol solution mixing, storage and automatic feed assembly designed to maintain minimum system pressure levels and complete with:

.1 A round, polyethylene or polypropylene tank sized to suit system capacity, complete with a solution level scale in litres and Imperial gallons, removable cover, and a welded steel angle stand assembly with legs, pump shelf, and control panel bracket, all factory finished with enamel.

.2 A factory pre-piped minimum 1/3 HP, 115-volt, 1 phase rotary bronze gear pump with capacity and pressure differential to suit system requirements, factory wired to the control panel, mounted on a shelf integral with the steel stand assembly, and complete with shut-off valve and strainer.

.3 A tank pressure relief valve with discharge piped back into the tank.

.4 A tank low level switch.

.5 A pressure gauge.

.6 A Honeywell #L404A "Pressurtrol" or equal pipe mounting differential pressure switch with a 100-1000 kPa (15-150 psi) range.

.7 A 115-volt, 1 phase, factory mounted and prewired control panel with an EEMAC 2 enamelled steel enclosure, designed to control and operate the glycol gear pump either manually or automatically to pump glycol solution into the system, and to stop the pump and initiate on audible/visual alarm if a low glycol solution level occurs in the tank, and complete with:

.1 Terminal blocks for power and control wiring connections.

.2 A H-O-A switch with green "Power On" indicator light.

.3 A 120 volt/12-volt control transformer.

.4 A low glycol solution level alarm buzzer with silencing switch, an alarm light which remains illuminated until the low-level switch is reset, and an alarm push-to-test button.

.5 Dry contacts for building automation system alarm annunciation.

.2 Acceptable products are:

.1 Ashland Water Technologies Model 5800

.2 ITT Bell & Gossett Series GMU

.3 S. A. Armstrong Ltd. GLA Standard Series

.4 Hamlet & Garneau Inc. AL Series

.5 HG Spec. Inc.

2.07 GLYCOL

.1 Propylene glycol blended with Nitrite based corrosion inhibitors.

2.08 BRAZED PLATE TYPE HEAT EXCHANGERS

.1 Vertical brazed plate type heat exchangers as per the drawing schedule, 1035 kPa (150 psi) working pressure rated, factory pressure tested and complete with:

.1 **Plates**: 316 stainless-steel corrugated channel plates with a filler material between each plate, designed for high-turbulence.

.2 **Brazing**: The heat exchanger is manufactured in a precisely controlled vacuum-brazing process that allows the filler material to form a brazed joint at every contact point between the plates, creating complex channels with high turbulence.

.3 **Cleaning-in-Place Connections:** Provide factory-installed connections to allow cleaning in place without disconnecting the heat exchanger.

.4 **Connections:** All connections are brazed to the BPHE in the general vacuum brazing process.

.5 Acceptable manufacturers are:

.1 S. A. Armstrong Ltd.

.2 Alfa Laval Inc.

.3 Baltimore Aircoil of Canada Inc.

.4 Tranter Heat Exchangers (Canada) Ltd.

.5 Danfoss Inc.

.6 Dover Corp. SWEP

3 EXECUTION

3.01 INSTALLATION OF PRESSURE RELIEF VALVES

.1 Provide factory set pressure relief valves where shown. Pipe the discharge of

each water piping relief valve to drain unless otherwise shown or specified.

.2 Pipe the discharge of each glycol solution piping relief valve back to the system expansion tank or return piping.

.3 Confirm relief valve settings.

3.02 INSTALLATION OF AIR VENTS

.1 Provide an air vent in piping mains at all high points, at equipment connections, and wherever else shown and/or specified. Equip each air vent with a ball type shut-off valve. Install vents in 100 mm (4") diameter and larger piping and all vents in mechanical rooms in accordance with the drawing detail.

.2 Provide 9 mm (3/8") diameter copper drain piping from each automatic air vent to nearest suitable drain and terminate so the discharge is visible. Identify the drain piping.

3.03 INSTALLATION OF PIPELINE STRAINERS

.1 Provide strainers in piping systems where shown on the drawings.

.2 Equip each strainer with a construction screen and remove after piping has been flushed and cleaned. Install permanent screens/mesh.

.3 Provide isolating valves in piping a maximum of 3 m (10’) from the strainer on each side of a strainer.

.4 For “Y” shaped strainers 40 mm (1½”) diameter and larger, provide blow-off piping complete with a shut-off valve with cap and chain, and terminate blow-off piping downward in a vertical position.

.5 For duplex basket strainers, equip each chamber drain plug with valved drain piping.

3.04 INSTALLATION OF AIR SEPARATOR

.1 Provide an air separator in piping where shown and connect with valved inlet and outlet piping.

.2 Extend valved blow-down piping from the bottom pipe connection tapping to the nearest floor drain location.

.3 Equip the top pipe connection tapping with an automatic air vent, and piping as detailed.

3.05 INSTALLATION OF EXPANSION TANK

.1 Provide expansion tanks where shown.

.2 Secure horizontal expansion tanks in place from the structure by means of

properly sized galvanized steel hanger rods and support saddles supplied with the tank.

.3 Secure vertical tank stand to a concrete housekeeping pad by means of machine bolts. Connect the tank with system piping as indicated.

.4 Connect the tank with system piping as indicated. Extend a drain line from the tank piping as indicated and terminate the drain line with a drain valve. Provide an air vent.

.5 For water systems without glycol, provide a water make-up connection line complete with relief valve and pressure gauge and connect to system piping as shown. Terminate the make-up piping for connection to domestic cold-water piping as part of the work of the mechanical work Section entitled Domestic Water Piping and Valves. Check relief valve operation and adjust as required.

.6 Check the tank air charge and adjust to suit the system.

3.06 INSTALLATION OF GLYCOL SOLUTION MIXING – STORAGE TANK

.1 Provide a mixing - storage tank and feed assembly for each glycol solution circulating system as shown.

.2 Secure the tank stand to a concrete housekeeping pad. Connect with system piping. Refer to the drawing detail.

.3 Fill the tank with, unless otherwise specified, a solution of 50% water, 50% propylene glycol, and test the solution to confirm proper concentrations.

.4 When installation is complete, test operation of the assembly, including alarms, and adjust as required. Adjust the pressure switch to suit the glycol solution circulating system pressure.

3.07 INSTALLATION OF PLATE TYPE HEAT EXCHANGERS

.1 Provide plate type heat exchangers where shown.

.2 Provide brazed plate heat exchangers where shown.

.3 As indicated on the drawings, secure each heat exchanger with an operating weight under 25kg (50lbs) in place, level, and plumb, either on a concrete housekeeping pad or securely wall mounted using demountable brackets.

.4 Secure each heat exchanger with an operating weight over 25kg (50lbs) in place, level, and plumb, on a concrete housekeeping pad.

.5 Connect with piping as per the drawing detail.

.6 When installation is complete and piping has been permanently filled, start-up each heat exchanger, check and test all safeties and operating controls, and set controls to design conditions.

.7 **Commissioning:** Refer to the mechanical work Section entitled Mechanical Work Commissioning.

.8 **Demonstration and Training:** Include for a one half-day on-site operation demonstration and training session. The training is to be a full review of all components including but not limited to a full operation and maintenance demonstration, with abnormal events.

3.08 INSTALLATION OF FLEXIBLE PIPING CONNECTIONS

.1 Provide flexible connections in piping connections to equipment where shown.

.2 Install in accordance with the manufacturer's instructions.

3.09 INSTALLATION OF THERMAL ENERGY METERS

.1 Contractor to install thermal energy meters forming part of the Building Automation System. BAS wiring by building automation system integrator.

3.10 INSTALLATION OF EQUIPMENT DRAINS AND PIPING DRAIN VALVES

.1 Unless otherwise shown or specified, provide a minimum 40 mm (1½") diameter type DWV copper drain piping from equipment overflows, condensate drain pans, pump bases, fresh air intake plenum drains, etc., to a floor drain location. Equip the drain piping with deep seal traps located in heated areas.

.2 Provide a drain valve at main shut off valves, the bottom of piping risers, at all other piping and apparatus low points, and wherever else shown and/or specified.

.3 Locate drain valves so that they are easily accessible.

END OF SECTION

PART 1 - GENERAL

1.1 Shop Drawings

.1 Submit shop drawings in accordance with Mechanical General Provisions 21 05 01.

.2 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers.

.3 Submit shop drawings of pump curves for review. Energy efficiency must at least equal to the basis of design equipment; this performance will be verified using an energy model by the Engineer prior to shop drawing approval.

.4 Indicate piping, valves and fittings shipped loose by packaged equipment supplier, showing their final location in field assembly.

1.2 Maintenance Data

.1 Provide maintenance data for incorporation into maintenance manual specified in Mechanical General Provisions 21 05 01.

PART 2 - PRODUCTS

2.1 In-Line Centrifugal Pumps

.1 General: Bronze fitted pump complete with motor.

.2 Shaft: stainless steel.

.3 Impeller: cast iron.

.4 Volute: cast iron, radially split, flanged suction and discharge, with drain plug, suction and discharge pressure tappings, Dura outside seal, EP 50FV.

.5 Motor: EEMAC Class B, open type drip proof P-base, continuous duty, drip proof, ball bearing maximum temperature rise 50 deg. C high efficiency type as specified in Section 21 05 01.

.6 Coupling: axially split, spacer type.

.7 CUNO filters: cartridge filter with ball type sight flow indicator.

.8 Provide variable frequency drives as shown on the pump schedule. Drives must be BACnet compatible.

.9 Capacity/size: see schedule.

.10 Basis of Design: Grundfos

.11 Acceptable manufacturers are: Bell and Gosset, Armstrong, Wilo.

PART 3 - EXECUTION

3.1 Installation

.1 In line centrifugal pumps: install as indicated by flow arrows. Support at flanges or near unions on outlets of unit. Install with bearing lubrication points accessible. Check rotation.

.2 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.

.3 If the main circulating pumps are used for flushing and cleaning the systems, replace pump seals with new ones prior to taking over the installation by the Owner.

END OF SECTION

PART 1 - GENERAL

1.1 Product Data

.1 Submit product data in accordance with Mechanical General Requirements 21 05 01.

1.2 Materials of Construction to be Avoided

.1 Specific materials of construction to be avoided in the piping system are Acrylate Rubber and ABS plastics. Contractor to verify with the supplier of thermofluid regarding other materisl to be avoided in the piping system.

.2 Contractor to provide pipe materials, valves, fittings and joints free from any of the above materials.

.3 Prior to fabrication and installation of piping system and materials, contractor to check with supplier of thermofluid for use of proper sealant for joints.

PART 2 - PRODUCTS

2.1 Pipe

.1 Steel pipe: to ASTM A53-86a, Grade 'B', Schedule 40.

.2 NPS 1/2 to 2, screwed.

.3 NPS 2-1/2 and over, plain end, welded.

.4 Copper (hard drawn) type 'L' to ASTM-B.88 for NPS 2 and under.

.5 Condensate Lines

.1 DWV copper with soldered joints.

2.2 Fittings

.1 For Steel Pipe, screwed, welded or grooved as follows:

.1 Malleable iron screwed fittings: Class 150 to ANSI B16.3-1977.

.2 Steel butt-welding fittings: to ANSI B16.9a-1981.

.3 Cast iron pipe flanges: Class 125 to ANSI B16-1-1975.

.4 Copper pipe fittings, wrought copper or cast brass. Provide dielectric fittings on copper to steel piping and copper pipe connections to steel equipment.

.5 Use 95-5 solder for joints.

.6 Grooved mechanical joints may be used. Couplings conform to ASTM-A536 and be complete with EPDM gasket, temperature -35^{O} C. to 110^{O}C. Couplings designed with angle bolt pads to provide a rigid joint unless otherwise noted.

.7 Standard of Acceptance: Victaulic 07 Zero-Flex.

.8 All grooved products, including couplings, fittings, valves and specialty items to be of one manufacturer.

.9 Victaulic pressfit system may be used in lieu of screwed joints on piping 50mm (2") or less.

2.3 Valves

.1 Gate Valves:

.1 NPS 1/2 to 2 screwed: rising stem; to MSS-SP-80-1979, Class 125, 860 kPa, bronze body, solid wedge disc.

.1 Standard of Acceptance: Crane 428; Jenkins 810J.

.2 NPS 2-1/2 and over: flanged, rising stem, to MSS-SP-70-1984 OS & Y bronze trim Class 125, 860 kPa, FF flange, cast iron body.

.1 Standard of Acceptance: Crane 465 1/2; Jenkins 454J.

.3 NPS 2 1/2 and over: flanged, non-rising stem; to MSS-SP-70-1984 class 125, 860 kPa, FF flange, cast iron body, bronze trim, bolted bonnet.

.1 Standard of Acceptance: Crane 461; Jenkins 452J.

.2 Globe Valves:

.1 NPS 1/2 to 2 screwed: to MSS-SP-80-1979, Class 150, 1 MPa, bronze body, screwed over bonnet, renewable composition disc.

.1 Standard of Acceptance: Crane 7; Jenkins 106BJ.
.2 Lockshield handles as indicated.

.2 NPS 2 1/2 and over, flanged: to MSS-SP-85-1985, class 125, 860 kPa, FF flange, cast iron body, bronze trim OS & Y, bolted bonnet, bronze disc and seat ring.

.1 Standard of Acceptance: Crane 351; Jenkins 2342J.

2.4 Ball Valves

.1 May be used in lieu of gate valves in sizes NPS 1/2 to 2 in systems operating at 1380 kPa and less.

.2 Valves shall be bronze body, stainless steel ball and teflon seat, brass stem and steel lever.

.3 Body shall have screwed ends.

.4 Standard of Acceptance: Crane 9302; Jenkins 901J.

2.5 Butterfly Valves

.1 May be used in lieu of gate valves in sizes NPS 2-1/2 and over in systems operating at 1380 kPa, and less. Where specifically shown on drawings, butterfly valves must be used. Install between 860 kPa flanges.

.2 Valves shall have iron body ductile iron, one piece or split stainless steel shaft, top and bottom bearings, bronze disc with stainless steel trim and EPDM liner.

.3 Body shall have threaded lugs.

.4 Valve shall have bubble tight shut-off to 1380 kPa pressure in either direction when the piping and connecting flange is removed from one side of the valve.

.5 Valves NPS 6 and smaller shall have lever operator with lock and gear operator for NPS 8 and over.

.6 Standard of Acceptance: Crane 50 55/B4E-L; Jenkins 2232 ELJ, with accessories as noted.

.7 Grooved-end butterfly valves may be used. Ductile iron body with dual seal, EPDM rubber coated ductile disc for bubble-tight shut-off to 2065 kPa.

.8 Standard of Acceptance: Victaulic Vic 300.

2.6 Swing Check Valves

.1 NPS 2 and under, screwed:

.1 To MSS SP-80-1979, class 125, 860 kPa, bronze body, bronze swing disc, screw in cap, regrindable seat.

.2 Standard of Acceptance: Crane 37; Jenkins 4092J.

.2 NPS 2-1/2 and over, flanged:

.1 To MSS SP-71-1984, class 125, 860 kPa, cast iron body, FF flange, regrinding disc, renewable seat, bronze disc, bolted cap.

.2 Standard of Acceptance: Crane 373; Jenkins 587J.

.3 NPS 2 and over, grooved-end pipe:

.1 To MSS SP-71, Class 125, 860 kPa, malleable or ductile iron body, bronze or stainless steel discs, EPDM seat.

.2 Standard of Acceptance: Victaulic 712, 715, 711.

2.7 Drain Valves

.1 Drain valves shall be for 1380 kPa non-shock WOG and shall be 19mm size gate valves with bronze body, male threaded garden hose end, cap and chain.

2.8 Balancing Valves

.1 Material of Construction: Ametal, Bronze Copper Alloy/Cast Iron, Ametal Trim.

.2 Operating temperature, max. 121^{o} C (250^{o} F).

.3 Working pressure, max. 1750kPa (250 psi).

.4 Connections: Screwed upto 50mm (2")
Flanged, 63mm (2-1/2") and over.

.5 Standard of Acceptance: Armstrong, type CBV I or CBV II to suit connections complete with fire rated pre-insulated cover to suit connections.

.6 Supplier of valve shall size the valves for the flow and pressure drop through piping.

.7 Include in the Tender Price for the supply of one (1) Armstrong 'Compu Flo-Meter' to be handed over to the owner at the completion of balancing of systems.

PART 3 - EXECUTION

3.1 Piping, General

.1 Connect to equipment in accordance with manufacturer's instruction unless otherwise indicated.

.2 Slope piping down in direction of flow to low points.

.3 Use eccentric reducers at pipe size change installed to provide positive drainage.

.4 Provide clearance for access for maintenance of equipment, valves and fittings.

.5 Ream pipes, clean scale and dirt, inside and out.

.6 Cap open ends during construction to prevent entry to foreign material.

.7 Make connection to equipment with unions or flanges. Install piping to minimize pipe dismantling for equipment removal.

.8 Threaded joints shall be made with sealant compatible with the thermofluid specified.

.9 Install grooved-end system as per manufacturer's recommendations.

3.3 Valves

.1 Install valves with stems upright or horizontal unless approved otherwise.

.2 Install valves at all branch take-offs to isolate each piece of equipment, and as indicated.

.3 If there is insufficient clearance for a rising stem valve use non-rising stem valve of same characteristics and manufacturer.

.4 Valves supplied for the units shall be of the same manufacture as those supplied for other mechanical systems.

.5 Where grooved piping concept is used in lieu of welded or threaded systems, grooved-end valves for isolation, check and control service shall be incorporated.

3.4 Testing

.1 Test system as described in Section 15010. Run system for minimum of twelve (12) hours and purge air from lines before balancing.

.2 When testing and balancing complete ensure that all valves are left in operating position, seal all test ports.

.3 Run system for a minimum of twenty-four hours and purge air from lines before balancing. Pressure test as indicated above.

END OF SECTION

PART 1 - GENERAL

1.1 Maintenance Materials and Service

.1 Contractor shall contract with chemical supplier to provide supervision and service for one year as follows.

.1 Field supervision for initiating fluid feed.

.2 Instruction of operation personnel in application and testing of fluid feed equipment.

.3 A minimum of six (6) site visits per year by a qualified water treatment specialist to conduct the required analysis at the site. Each site visit to be covered by a written report.

.4 Supplier to provide adequate inhibitor and add chemicals as required.

.5 After adding new chemicals, contractor/supplier shall check and verify adequacy and level of inhibitor of all of the existing piping system. Add additional chemicals as required.

1.2 Installation

.1 The Mechanical Contractor shall supply the Engineer with certified documentation that the cleaning of the system and additon of inhibitor and chemical feed has been approved by chemical supplier, and the Owner's operating personnel have been instructed.

.2 Cleaning and Flushing

.1 The supplier of the chemical treatment equipment and cleaning chemicals shall supervise the entire cleaning and flushing operation of the system.

.2 The supplier shall ensure the following:

.1 The system is flushed of all sand, gravel and fillings before cleaner is added.

.2 The proper strength of cleaner is added and circulated for the prescribed time.

.3 The system is thoroughly flushed again before chemicals are added.

.4 Before connecting the heat pumps into the piping loop, the flexible connectors shall be joined together and the manufacturer’s recommendations for flushing and testing of the piping be followed. Isolate heat pumps while flushig the system.

END OF SECTION

PART 1 - GENERAL

1.1 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Mechanical General Provisions 21 05 01.

1.2 Compliance

.1 Comply with SMACNA HVAC Duct Construction Standards, Metal and Flexible, 1995, Second Edition.

PART 2 - PRODUCTS

2.1 Sealant

.1 Sealant: oil resistant, polymer type flame resistant high velocity duct sealing compound. Temperature range of minus 30 deg. C. to plus 93 deg. C.

.1 Standard of Acceptance: Duro Dyne S-2.

2.2 Duct Classification and Leakage

.1 Ductwork shall be manufactured suitable for low pressure, upto and including 938 Pa.

.2 Seal classification, to suit ductwork.

2.3 Fittings

.1 Fabrication: to SMACNA HVAC Duct Standards.

.2 Radiussed elbows: standard radius and/or short radius with single thickness turning vanes.

.3 Square elbows: to 400mm with single thickness vanes.

.4 Square elbows: over 400mm with double thickness vanes.

.5 Main supply duct branches with splitter damper.

.6 Sub branch duct with 45 deg. entry and balancing damper on branch or sub branch duct with square connection, extractor and branch duct balancing damper.

.7 Transitions:

.1 Diverging: 20 deg. maximum included angle.

.2 Converging: 30 deg. maximum included angle.

2.3 Fittings (cont.)

.8 Offsets: square elbows, radiussed elbows.

.9 Obstruction deflectors: maintain full cross-sectional area. Maximum included angles as for transitions.

2.4 Firestopping

.1 Retaining angles all around duct, on both sides of fire separation.

.2 Firestopping material and installation must not distort duct.

2.5 Galvanized Steel

.1 Lock forming quality, thickness, fabrication and joints: to SMACNA HVAC Duct Construction Standards.

2.6 Hangers and Supports

.1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.

.2 Hanger configuration: maximum size duct supported by strap hanger shall be 500mm.

.3 Hangers: galvanized steel angle with black steel rods to the following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
501 to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 50 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

.4 Upper hanger attachments:

.1 For concrete: manufactured concrete inserts.
.1 Standard of Acceptance: Myatt fig. 485.

.2 For steel joist: manufactured joist clamp or steel plate washer.
.1 Standard of Acceptance:
(i) Grinnell fig. 61 or 86 for joist clamps.
(ii) Grinnell fig. 60 for plate washer.

.3 For steel beams: manufactured beam clamps:

.1 Standard of Acceptance: Grinnell fig. 60.

.4 For wood structure: use suitable stainless steel lag bolts.

2.7 Fire Stopping Materials

.1 All penetrations of fire walls and fire separations by pipes, conduits, cables or ducts shall be restored to original fire ratings. Fire stopping materials shall be used to seal openings around any such penetrations.

.2 Material: Heat activated, non-hardening putty.

PART 3 - EXECUTION

3.1 Installation Requirements

.1 Install ducts in accordance with SMACNA HVAC Duct Construction Standards.

.2 Do not break continuity of insulation vapour barrier with hangers or rods. Insulate strap hangers 100 mm beyond insulated duct.

.3 Seal all joints with high velocity sealing compound.

3.2 Hangers

.1 Strap hangers: install in accordance with SMACNA HVAC Duct Construction Standards.

.2 Angle hangers: complete with locking nuts and washers.

.3 Hanger spacing as follows:

Duct Size (mm)	Spacing (mm)
to 1500	2500
1501 and over	3000

3.3 Sealing

.1 Apply sealant to outside of joint to manufacturer's recommendation

3.4 General

.1 Provide ducts and sheet metal shown and as required to complete duct systems and put each in operating condition. Sheet Metal Trade is responsible for laying out this work. Drawings showing ducts must not be used for obtaining dimensions for layout except where dimensioned. Mechanical drawings indicate general location and route of ductwork to be installed. General layout of ducts may be taken from drawings but this Section is responsible for avoiding

interferences with other Sections not specifically shown on Mechanical drawings. Actual measurements shall be taken at building before ductwork is fabricated.

.2 Seal and weatherproof ducts passing through roof. Solder all joints and seams. Degrease and prime paint any ferrous counterflashings.

.3 Form ducts with gauge markings on exterior of ductwork visible from floor.

.4 Make joints suitably air tight with laps in direction of air flow. Wherever possible, sizes of ducts shall conform to those indicated. Where building conditions require shape to be modified, ducts must have same cross-sectional area indicated and width of duct shall not exceed six times depth except with special approval.

.5 Install in ductwork where shown or required, controls, thermometers, etc., in accordance with setting instructions supplied by equipment supplier.

.6 Make radius of turns at least one duct width. Where space prevents such radius, make turn square and fit with turning vanes of double faced hollow type with Duro Dyne vane-rails secured with sheet metal screws.

.7 Provide manual balancing damper where shown and as required to balance the system. Make turning vanes, deflectors of same material and thickness as for equal size ductwork with formed edges, cross-broken and stiffened.

.8 Install grilles, registers and diffusers to manufacturer's direction. Supply and install baffles in diffusers to suit air pattern. Adjust grilles and registers to give required air throw and pattern.

.9 Provide extension collars for outlets, air guide vanes and other special features as indicated or required including connections to equipment. Transition ducts at not more than 30 degree slope to full size of each grille, register or equipment.

.10 Paint inside of duct connections behind each grille and register with two coats of black non-reflective paint to visually conceal duct interior to approval.

.11 Install ductwork to clear structural members and any fire-proofing. Locate ducts to permit their proper insulation where required. Do not remove or damage structural fireproofing. Leave space to permit insulation and fireproofing to be inspected and repaired.

.12 Ducts passing through roof shall have suitable approved minimum 357mm (14") high curb built and flashed over by this Section. Counter flashing of ducts by this Section, of same material and finish as flashing.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Provide Sound Attenuation in accordance with ASTM E477-84, ASTM E90-85 and ASTM C423-84a, except where specified otherwise.

1.2 Shop Drawings

.1 Submit shop drawings in accordance with Section 21 05 01.

.2 Provide separate shop drawings for each piece of attenuation equipment or materials complete with product data.

1.4 Acoustical Insulation

.1

PART 2 - PRODUCTS

2.1 Acoustical Insulation

.1 Insulation shall be equal to Johns Manville Linacoustic RC-HP high density duct liner.

.2 Provide 25mm thick duct liner for minimum 3m in supply and return ductwork for each water to air heat pump unit, the supply and return exhaust ductwork serving the heat recovery unit, and transfer air ductwork where shown on drawings.

PART 3 - EXECUTION

3.1 Installation

.1 Install in accordance with manufacturer's instructions.

END OF SECTION

PART 1 - GENERAL

1.1 Product Data

.1 Submit product data in accordance with Section 15010.

.2 Indicate the following:

.1 Flexible connections.

.2 Sealants and tapes.

.3 Duct access doors.

.4 Turning vanes.

.5 Instrument test ports.

1.2 Certification of Ratings

.1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

PART 2 - PRODUCTS

2.1 Flexible Connections

.1 Frame: galvanized sheet metal frame 2mm (3/32") thick with fabric clenched by means of double locked seams.

.2 Material: fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40° C to plus 90° C (minus 40° F to plus 220° F), density of 1.3 kg/m^2 (0.3 lb/ft^2).

.3 Standard of Acceptance: Alpha-Flex.

2.2 Access Doors in Ducts

.1 Non-insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6mm (.023") thick complete with sheet metal angle frame.

.2 Insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6mm (.023") thick complete with sheet metal angle frame and 25mm (1") thick rigid glass fibre insulation.

.3 Gaskets: neoprene or foam rubber.

.4 Hardware:

.1 Up to 300mm x 300mm (12" x 12"): two (2) sash locks complete with safety chain.

.2 301mm to 450mm (12" to 18"): four (4) sash locks complete with safety chain.

.3 451mm to 1000mm (18" to 40"): piano hinge and minimum two (2) sash locks.

.4 Doors over 1000mm (40"): piano hinge and two (2) handles operable from both sides.

.5 Hold open devices.

2.3 Turning Vanes

.1 Factory or shop fabricated single thickness or double thickness with trailing edge, to recommendations of SMACNA and as indicated.

PART 3 - EXECUTION

3.1 Installation

.1 Flexible connections: Install in following locations:

.1 Inlets and outlets to supply air units and fans.

.2 Inlets and outlets of exhaust and return air fans.

.3 As indicated.

.4 Length of connection: 150mm (6").

.5 Minimum distance between metal parts when system in operation: 75mm (3").

.6 Install in accordance with recommendations of SMACNA.

.7 When fan is running:

.1 Ducting on each side of flexible connection to be in alignment.

.2 Ensure slack material in flexible connection.

.2 Access doors:

.1 Size:

.1 650mm x 450mm (26" x 18") for person size entry.

.2 550mm x 350mm (22" x 14") for servicing entry.

.3 200mm x 150mm (8" x 6") for viewing.

.4 As indicated.

.2 Location:

.1 At fire and smoke dampers.

.2 At control dampers.

.3 At devices requiring maintenance.

.4 At locations required by code.

.5 At coils.

.6 As indicated.

.3 Turning vanes:

.1 Install in accordance with recommendations of SMACNA HVAC Duct Construction Standards and as indicated.

END OF SECTION

PART 1 - GENERAL

1.1 Product Data

.1 Submit product data in accordance with Mechanical General Requirements 21 05 01.

PART 2 - PRODUCTS

2.1 Multi-Blade Dampers

.1 Factory manufactured of material compatible with duct.

.2 Damper Frame: extruded aluminum, 2.03mm (0.08”) thick, 100mm (4”) deep.

.3 Blades: extruded aluminum.

.4 Blade Gaskets: EPDM elastomer.

.5 Linkage: aluminum and corrosion resistant zinc and nickel plated steel.

.6 Operating Temperature Range: -40^{o} C. to 100^{o} C. (-40^{o} F. to 212^{o} F.)

.7 Standard of Acceptance: TAMCO 1000, except as noted below.

PART 3 - EXECUTION

3.1 Installation

.1 Install where indicated.

.2 Install in accordance with manufacturer's instructions.

.3 Dampers shall be installed external to ductwork with flanged connection. Oversize dampers to provide flanged connection.

.4 Provide single blade dampers for duct sizes 200mm (8”) and under, any dimension.

END OF SECTION

PART 1 - GENERAL

1.1 Product Data

.1 Submit product data in accordance with Mechanical General Requirements 21 05 01.

.2 Indicate: dimensions, operating limits and fire rating for the following.

.1 Fire dampers.

1.2 Maintenance Data

.1 Provide maintenance data for incorporation into maintenance manual specified in Mechanical General Requirements 21 05 01.

1.3 Certification of Ratings

.1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

1.4 Integrity of Fire Separation

.1 Provide fire dampers to maintain integrity of all fire separations.

.2 Refer to Architectural drawings for the extent of fire separation and fire walls.

PART 2 - PRODUCTS

2.1 Fire Dampers

.1 Fire & smoke dampers: listed and bear ULC label and shall meet requirements of Ontario Fire Marshal.

.2 Mild steel or stainless steel, factory fabricated for fire rating requirement to maintain integrity of fire wall and/or fire separation.

.3 Top hinged: multi-blade hinged or interlocking type; sized to maintain full duct cross section.

.4 Fusible link actuated, weighted to close and lock in closed position when released or having negator-spring-closing operator for multi-leaf type or roll door type in horizontal position with vertical air flow.

.5 Frame and 40mm x 40mm x 3mm angle iron on full perimeter of frame on both sides or fire wall and/or fire wall being pierced.

.6 Fire dampers shall be type 'B' for maximum free area.

.1 Acceptable fusible link damper manufacturers are:

.1 Nailor Industries Inc.

.2 Greenheck Fan Corp.

.3 NCA Manufacturing Ltd.

.4 Ruskin Co.

2.2 Firestop Flaps

.1 Listed and shall bear ULC label and meet requirements of Ontario Fire Marshal.

.2 Constructed of minimum 1.5mm (0.06") thick sheet metal with 1.6mm (0.06") thick non-asbestos. ULC listed insulation and corrosion-resistant pins and hinges.

.3 Flaps to be held with fusible link conforming to ULC-S505-1974 and close at 74ºC (165ºF) or to suit the application.

.4 Acceptable fusible link damper manufacturers are:

.1 Nailor Industries Inc.
.2 Greenheck Fan Corp.
.3 NCA Manufacturing Ltd.
.4 Ruskin Co.
.5 Controlled Aire

2.3 Combination Fire/Smoke Dampers

.1 Provide Fire/Smoke Dampers, as shown on drawings and/or schedules, Dampers shall meet the requirements of NFPA 80, 90A, 92, 101 and 105. Dampers shall be qualified for use in dynamic or static smoke control systems. Dampers shall be classified by Underwriters Laboratories and labeled as a 1 1/2 hour Dynamic Fire Damper under UL 555 and as a Class I Leakage Rated Smoke Damper under UL 555S at an elevated temperature of 250°F (121°C).

.2 Dampers shall be supplied with factory installed sleeves, dependent on wall thickness, minimum 16” (406) length. Sleeve length shall be field verified by contractor. Frame/integral sleeve shall be roll-formed from 20 ga. (1.0) galvanized steel, beaded for structural strength and grooved to accept 20 ga. (1.0) galvanized steel retaining plate.

.3 Each damper shall be complete with retaining plate and 20 ga. (1.0) galvanized steel damper plate, supplied by the damper manufacturer to ensure proper fit and installation. Blade shall be of two 20 ga. (1.0) galvanized steel pieces laminated together with an equivalent thickness of 14 ga. (2.0).

.4 Blade seal shall be silicone rubber sandwiched between blade pieces and shall completely encircle blade periphery. Blade axles shall be 1/2” (13) dia. plated

steel double bolted to blade. Hex, square friction-fit or press-fit axles are not acceptable. Bearings shall be self-lubricating oilite bronze type.

.5 Appropriate externally mounted electrical actuators shall be installed by the damper manufacturer in the factory. Actuators shall incorporate an OEM internal spring mechanism; external after-market spring mechanisms are not acceptable. Damper and actuator assembly shall be factory cycled a minimum of 3 times to ensure correct operation.

.6 Each damper shall be equipped with UL Classified heat responsive device that will cause the damper to close in a controlled manner and lock in a closed position by means of an over-center/knee lock linkage when the duct temperature reaches the maximum degradation temperature of the damper/actuator assembly, as required by UL 555S. Closure devices that cause instantaneous closure are not acceptable.

.7 Acceptable combination fire/smoke dampers are:

.6 Nailor Industries Inc.

.7 Greenheck Fan Corp.

.8 NCA Manufacturing Ltd.

.9 Ruskin Co.

.8 Damper manufacturer shall submit pressure drop data to be based on tests in accordance with AMCA Standard 500-D.

PART 3 - EXECUTION

3.1 Installation

.1 Install fire dampers in accordance with NFPA 90A-1981.

.2 Maintain integrity of fire wall and/or fire separation. Fire dampers shall be properly sleeved and fire stopped with suitable fire stopping material around the sleeve.

.3 After completion and prior to concealment, obtain approvals of complete installation.

.4 Provide minimum 400mm x 400mm access door for all fire dampers.

END OF SECTION

PART 1 - GENERAL

1.1 Reference Standards

.1 Comply with requirements of:

.1 ULC S110M-1980 for fire tests for air ducts.

.2 UL 181-1981 for factory made air ducts and connectors.

.3 NFPA 90A-1981 for installation of air conditioning and ventilating systems.

.4 NFPA 90B-1980 for installation of warm air heating and air conditioning systems.

.5 SMACNA HVAC Duct Construction Standards for flexible ducts.

.6 Flexible ducts will only be accepted in ceiling spaces with accessible drop ceilings

PART 2 - PRODUCTS

2.1 General

.1 Factory fabricated.

.2 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

.3 Spiral wound flexible aluminum, insulated type.

PART 3 - EXECUTION

3.1 Duct Installation

.1 Provide flexible ducting only where indicated on the drawings.

.2 Support with angle and rods.

.3 Maximum length of flexible duct: 2m.

END OF SECTION

PART 1 - GENERAL

1.1 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Mechanical General Requirements 21 05 01.

.2 Product data to include fan curves and sound rating data.

1.2 Operation and Maintenance Data

.1 Provide operation and maintenance data for incorporation into maintenance manual specified in Mechanical General Requirements 21 05 01.

1.3 Manufactured Items

.1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards in force.

.2 Provide confirmation of testing.

PART 2 - PRODUCTS

2.1 Fans General

.1 Provide, as indicated, for airflow, total static pressure, r/min, bhp or W, model and size and sound ratings.

.2 Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum catalogued operating speed. Bearings shall be of air handling quality.

.3 Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing.

.4 Sound ratings shall comply with AMCA 301-76 tested to AMCA 300-67.

.5 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99-76.

.6 Ratings: based on tests performed in accordance with AMCA 210-74, and ASHRAE 51-75.

.7 See Exhaust Fan Schedule on drawings and where noted on drawings.

.8 Standard of Acceptance: 'Greenheck', models as noted.

PART 3 - EXECUTION

3.1 Installation

.1 Install in accordance with manufacturers instructions.

.2 Provide interlocking of fans as indicated on drawings.

.3 Provide accessories as indicated on drawings.

END OF SECTION

PART 1 - GENERAL

1.1 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Mechanical General Provisions 21 05 01.

1.2 Maintenance Data

.1 Provide maintenance data for incorporation into maintenance manual specified in Mechanical General Provisions.

1.3 Manufactured Items

.1 Grilles, registers and diffusers shall be product of one manufacturer.

.2 Acceptable manufacturers are:

.1 Price Industries Inc.

.2 Mestek Co. “Anemostat”

.3 Krueger Division of Air System Components Inc.

.4 Titus

.5 Nailor Industries Inc.

1.4 Certification of Ratings

.1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

PART 2 - PRODUCTS

2.1 General

.1 Provide standard product to meet capacity, throw, noise level, throat and outlet velocity.

.2 Where grilles, registers and diffusers penetrate fire walls and fire partitions, provide approved steel sleeve secured to structure in accordance with NFPA 90A-1981.

.3 Frames:

.1 Aluminum: extruded with mechanical fasteners and mitered corners. Colour: off-white.

.2 Provide full perimeter gaskets.

.3 Provide plaster frames as plaster stops where set into plaster or gypsum board.

.4 Models, sizes and capacities: as scheduled and where shown on plan drawings.

.5 Standard of Acceptance: E. H. Price.

PART 3 - EXECUTION

3.1 Installation

.1 Provide grilles and diffusers where shown on the drawings. Wherever possible, grilles and diffusers are to be the product of one manufacturer.

.2 Unless otherwise specified connect grilles and diffusers in accordance with requirements of SMACNA HVAC Duct Construction Standards Metal and Flexible.

.3 Exactly locate grilles and diffusers to conform to the final architectural reflected ceiling plans and detailed wall elevations, and to conform to the final lighting arrangement, ceiling layout, ornamental and other wall treatment.

.4 Equip supply diffusers having a basic four-way or all-round air pattern for operation in one, two, or three-way pattern where indicated on the drawings.

.5 Provide sheet metal plenums, constructed of the same material as the connecting duct, for linear grilles and/or diffusers where shown. 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).

.6 Where linear type diffusers/grilles are installed in suspended T-bar ceilings, clip the diffusers/grilles in place using clip supplied by the diffuser/grille manufacturer.

.7 Confirm grille and diffuser finishes prior to ordering.

.8 Bolt grilles, registers, and diffusers in place and provide safety chains in in areas where the grille, register and diffuser may be subject to damage.

.10 Paint duct behind diffuser or grille with black paint.

END OF SECTION

PART 1: GENERAL

1.1 SUMMARY

.1 This section includes Dedicated Outdoor Air System (DOAS) units for indoor applications.

1.2 SUBMITTALS

.1 Product Data: Submit product data for specified products with the following information:

.1 General layout drawing with plan and elevation views including are relevant dimensions
.2 Performance schedule including airflow, heating and cooling capacities, electrical data, unit weight.
.3 Full fan curve.
.4 Sound power data by octave band for all openings and radiated through cabinet.
.5 Electrical schematics including field wiring connections.
.6 Component details including construction method and materials.
.7 Control point schematic and complete written sequence of operation.
.8 Curb mounting details.

1.3 QUALITY ASSURANCE

.1 Safety Listings
.1 Entire unit shall be UL 1812 or UL 1995 certified and bear certification label by ETL, UL or CSA.
.2 Unit shall meet ASHRAE Standard 90.1 performance requirements and shall be **PASSIVE HOUSE CERTIFIED**.

1.4 DELIVERY, STORAGE AND HANDLING

.1 Storage and protection
.1 Store equipment away from construction areas where it may be damage and protected from harmful weather conditions.
.2 Keep factory shipping packaging in place until unit is ready to be installed.
.1 Rigging

1. Follow manufacturer’s instructions for rigging and placement of equipment.

1.5 COORDINATION

.1 A Coordinate all system connections and building penetrations including electrical, gas and duct connections.
.2 B Coordinate curb placement, structural and roofing.

PART 2: PRODUCTS

2.1 MANUFACTURERS

.1 Standard of Acceptance: SWEGON
.2 Alternates proposed by the contractor shall meet size, weight, performance and arrangement shown on the drawings.

2.2 DOAS UNITS

.1 DOAS units shall be factory assembled and tested. Units shall include insulated steel cabinet with steel base, total recovery enthalpy wheel, fan and motor assembly, filter rack, and integral controls. Unit shall have single point power connections.

2.3 CABINET

.1 Cabinet shall be nominal 2 inch double wall panel Roxul acoustic and thermal insulation. Insulation shall have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50. Cabinet exterior shall be 20 gauge prepainted steel that meets or exceeds 650 hour salt spray test based on ASTM B117. Liners and other steel components shall be galvalume steel. All seams shall be sealed to provide air tight casing. Outdoor unit roofs shall have 3 break standing seams.
.2 Doors shall be nominal 2 inch double wall panel with the same construction as cabinet. Doors shall be fitted hinges with flush mounted door handles. The doors shall have one lockable handle as standard and the handles shall have a two stage opening for improved safety.
.3 The unit will be designed for service and maintenance on one side only to allow for a compact installation.
.4 Units shall be tested in accordance with EN 1886 or equivalent and meet the following criteria;
    .1 Casing air leakage = A
    .2 Thermal transmittance = T3
    .3 Thermal bridging factor = TB3
    .4 Air tightness class L2
    .5 Environmental Class C4
.5 Units shall be designed so they can be unbolted and broken down into sections for access to restricted locations. All interconnecting wiring shall have quick connect harnesses at each section.
.6 All dampers shall have extruded heavy gauge 6063 aluminum frame that includes jamb seals. Blades shall be airfoil shaped extruded aluminum and include rubber blade seals. Linkage shall be installed in the frame outside of the airstream.
.7 All dampers shall include factory mounted, wired and tested actuators. Dampers shall be two position as required.

2.4 FILTERS

.1 Unit shall include side loaded cartridge filter rack suitable for 12", 10 pocket MERV 13 bag filters. Filters will be held in position by an expanding locking device that provides a seal on all four sides of filter.
.2 Provide factory mounted pressure sensors to measure filter pressure drop across pre-filter and main filter. Pressure drop shall be digitally feedback to controller for utilization in control and alarm sequencing. Unit controller shall monitor filter pressure level and report when filter changes are required.

2.5 FANS

.1 Fans shall be mixed flow plenum type with direct drive motor. Fan and motor assembly shall be mounted on common base with internal isolation. Fan shall be connected to fan bulkhead by a canvas type flex connector. The fans will be capable of operating in ambient temperatures of up to 104°F.
.2 Fan motors shall be permanent magnet, synchronous motor type with integral digital motor controller. Fan bearings shall be serviceable type with an L-10 life of 40,000 hours.
.3 Fans shall be provided with Variable Frequency Drives integrated with the unit controller.
.4 All fans shall be equipped with integral airflow monitoring system connected to the unit controller.
.5 Provide means to easily remove fan-motor assembly for service through standard doors. Wiring must be quick connect fittings. Hard wiring will not be acceptable.
.6 Fans should be designed such that all service can be performed in the field, including replacement of bearings.

2.6 ENERGY RECOVERY DEVICE

.1 Units shall include AHRI 1060 certified rotary heat exchanger that transfers both sensible and latent energy. Wheel shall be constructed of corrugated aluminum coated with desiccant. Desiccant material shall be 3A or smaller molecular sieve. Wheel supports shall be galvanized steel with a rigid steel hub. Cassette shall be heavy duty reinforced galvanized steel with a built in purge section. Bearings shall be permanently sealed type. Rotary heat exchanger shall include adjustable face and peripheral brush seals. Drive motor shall be variable speed type capable of operating to 1 rpm and integrated into unit controller.
.2 Rotary Heat Exchanger carry over must not exceed 0.45% and be certified to EN308:1997.
.3 Provide airflow monitor to measure outdoor airflow through enthalpy wheel. Monitor shall be integrated into unit controller. Airflow accuracy shall be minimum ± 5% of design airflow.

2.9 CONTROLS

.1 Unit shall include an integrated microprocessor based unit controller. Controls shall be BACnet compatible. The controls shall be located in the integral controls cabinet. All controls shall operate off a transformer from the main power supply for single point power connection. All internal controls and sensors shall be factory prewired and tested. The microprocessor shall have dual Ethernet ports with an internal firewall to allow remote access via third party without compromising the clients internal Network.

.2 Include with each unit touch pad type human interface that allows monitoring and control of all unit functions. Human interface shall communicate with unit controller by hardwire [wireless] connection. Human interface shall be unit [remote] mounted.

.3 The control system will regulate temperatures, airflows and other functions as required. Unit controller shall be pre-programmed with factory test software for all possible functions. Controller shall utilize “plug and play” feature that will automatically load and operate any necessary algorithm based on components and accessories that are connected to the controller such as air flow monitors, damper actuators, fans, rotary energy recovery, water control valves, etc.

.4 The controller shall provide the following: refer to sequence of operation for specific unit control sequences;

- .1 Control of fans correcting for both changes in total static pressure and air density in both VAV and constant airflow applications.
- .2 Fan performance monitoring.
- .3 Ventilation airflow monitoring and control.
- .4 Airflow density correction for winter and summer conditions.
- .5 Energy recovery optimization including operation of rotary energy recovery device.
- .6 Supplemental heating and cooling when included.
- .7 Integration to VRF condensing units when included.
- .8 Frost protection.
- .9 Recirculation module when included.
- .10 Monitoring alarms, faults and maintenance points including filter changeout.
- .11 Time and date schedules.
- .12 Building pressurization.
- .13 Humidity control.
- .14 Data logging and trending.

.5 Include wireless capability that will allow the client to access remotely via Smart Phone or IPad or Similar device without supplemental software.

.6 If non factory controls are proposed as an option, a factory witness test is required to show integration and functionality.

.7 Controller shall be native BACnet certified and also include Modbus communication. Communication shall include monitoring, control, alarms, faults and maintenance information.

.8 Provide factory installed and tested contactors, overloads, fusing, starters motor speed controllers for supply, exhaust and rotary energy recovery device. Include all necessary control transformers.
.9 Provide unit mounted non-fused disconnect switch with single point power connection.
.10 Supply all necessary temperature and pressure sensors complete with plug in wiring harnesses for proper option of unit.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment in accordance with manufacturer instructions, these specification, best practices and all applicable building codes.

3.2 START UP SERVICE

.1 Engage a factory authorized service technician to start up and commission units. Provide start up report to owner and engineer.

END OF SECTION

PART 1 - GENERAL

1.1 Shop Drawings and Product Data

.1 Submit shop drawings and product data in accordance with Mechanical General Requirements 21 05 01.

.2 Indicate the following: fan, fan curve, motor drive, bearings, filters, and performance data.

.3 Provide data demonstrating full and part load energy efficiency (winter and summer) at least equal to the basis of design equipment; this performance will be verified using an energy model by the Engineer prior to shop drawing approval.

1.2 Maintenance Data

.1 Provide maintenance data for incorporation into manual specified in Mechanical General Requirements 21 05 01.

.2 Include the following: fan, bearings, motor and filters.

1.3 Manufactured Items

.1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards in force.

PART 2 - PRODUCTS

2.1 Water-to-Air Units

.1 General

.1 Factory assemble components, to form units supplying air at designed conditions, as indicated.

.2 Certify ratings to ARI. Unit shall bear CSA seal.

.3 Horizontal type having air tight modular components, consisting of casing, fan, motor and drive, compressor, motor, coils, fan and filters.

.4 Note: The equipment selections and layouts are based on ‘Climate Master’ units. If any other equipment is selected, it is the Contractors responsibility to make changes to layouts, electrical requirements and bear the cost of any associated modifications.

.2 Each heat pump shall contain a sealed refrigerant circuit consisting of a hermetic motor-compressor, air to refrigerant tube coil, capillary expansion tube, pilot-operated refrigerant reversing valve, cupro-nickel water-to-refrigerant exchanger, high pressure and low temperature safety cutouts, all contained within an acoustically lined unit casing. Air side shall include blower, motor, filter and drain pan sections. Integral control section shall include all operating and safety controls as specified. All units must be CSA approved and must bear the CSA monogram. Each unit shall be supplied with disconnect switch.

.3 Manufacturer shall guarantee heat pump units to start and operate with entering air temperature 10^{o} C. (50^{o} F.) and entering fluid temperature between -3.8^{o} C. an 43.3^{o} C. (25^{o} F. and 110^{o} F.).

.4 A five (5) year warranty shall be provided by Contractor for furnishing parts and labour for replacing any part of the unit which becomes defective in normal operation from the date of original installation.

.5 Provide the following accessories:

- Bi-flow expansion valves;
- Collar for filter;
- Filters;
- Float switch for drain pan interlocked to shut unit down in case of plugged condensate drains;
- Mute acoustic package;
- Fire rated hose kits;
- Freezestats

.6 Furnish the services of a trained representative of the heat pump unit manufacturer to supervise the installation, starting and testing of all units, in accordance with the manufacturer's instructions. Upon completion of the installation the heat pump unit manufacturer shall provide, to the Owner, their written report on the installation and operation of these units.

.7 Heat Pump System Controls

The heat pump supplier shall include in his bid and be responsible for:

.1 Mounting and wiring of all safety controls and overrides in units.

.8 Installation Requirements

.1 Power supply to panel shall be 208 volts, 60 cycle, 3 phase or single, except as noted.

.2 Coordinate with Electrical Division all field wiring from panel to heat pump units and control circuits.

.3 Provide a control wiring diagram for approval and also provide the required starters, relays and controls to ensure proper operation of the system.

.4 Manufacturer's representative shall check out installation of this panel and shall verify the setting of controls and alarms.

.9 System Start-Up

.1 Set up and adjust all controls, controllers, thermostats, and equipment to the required settings, and check out operation of each of the units. This Section shall clean all equipment and ensure clean filters have been installed before start-up of any heat pump shall be operated first on

"Cool" and then on "Heat" modes, before thermostats are set at 23^{o} C. (73^{o} F.) for normal operation in cooling mode and 21^{o} C. (70^{o} F.) in heating mode.

.2 A factory trained manufacturer's service representative shall supervise the adjustment and start-up of system equipment and each unit. Heat pump manufacturer shall be responsible for above requirements and for demonstrating the proper operation of the systems, equipment, and each heat pump unit.

.10 Basis of Design: Trane

.11 Acceptable manufacturers are: Waterfurnace; Climatemaster; FHP Bosch Group; Modine; Carrier; York.

2.2 Water-to-Water Units

.1 Cabinet shall be of 16 gauge baked enamel steel suitably reinforced to contain the compressors with anti-vibration dampers. All panels shall allow field removal to provide easy access to all components for easy servicing.

.2 Refrigerant to fluid heat exchanger shall be high efficiency tube-in shell design with integral receiver and true counter-flow arrangement. Water side design pressure shall be 860 kPa (125 psi) and refrigerant side presssure shall be 2580 kPa (375 psi) minimum.

.3 Refrigerant circuit shall be fully contained in the unit cabinet and shall be properly charged, sealed and leak tested before leaving factory. Provide all safety controls, factory installed and tested. Provide factory mounted terminal block for easy field wiring. Reversing valve shall be pilot operated and solenoid activated.

.4 Compressor shall be fully hermetic high efficiency type for quiet operation.

.5 Provide 24 VAC, 100 VA control circuit.

.6 Provide the following accessories for each unit:

.1 Microprocessor controller to provide high pressure, low temperature and loss of refrigerant protection, LED display of unit status and cause of lockout, return water temperature control for staging, anti short cycle and random start.

.2 Unfused disconnect switch.

.7 Basis of Design: “Compax”.

.1 Acceptable manufacturers are: Waterfurnace; Climatemaster; FHP Bosch Group; Modine

PART 3 - EXECUTION

3.1 Installation

.1 Install units in accordance with manufacturer's instructions and as indicated on drawings.

.2 Install units such that other trades will not impede access to service unit and filter removal and installation. It is this section's responsibility to ensure that no subsequent trade encroaches on or interferes with servicing access and filter removal and replacement.

.3 Provide access panels in drywall ceilings, (fire-rated if required) suitable to fully access the units.

3.2 Fans

.1 Install fan sheaves required for final air balance.

.2 Install 200mm long flexible connections at fan outlets. Ensure metal bands of connectors are not touching when fan is running and when fan is stopped.

3.3 Drip Pans

.1 Install deep seal P-traps on drip lines.

3.4 Performance Schedule

.1 See Schedule for heat pump units.

3.5 New Filters

.1 Prior to handing over the system, install new filters in all units. (Filters used in the units during commissioning and testing shall not be re-used).

END OF SECTION

PART 1 - GENERAL

1.1 General Requirements and Conditions

1. This section applies to the material and installation techniques for the geothermal ground exchanger.

2. This Contractor shall provide all necessary materials, equipment and labour for a complete geothermal heat pump ground heat exchanger (ground loop) system. Include all work to approximately 300mm (12") above finished floor elevation at sub-manifold locations, as shown on the project drawings. Provide adapters from HDPE plastic to brass nipple adapter capped and ready for connection by Division 15000 Contractor.

3. Retain and pay for the services of an experienced Geothermal System Consultant who is a registered professional engineer licensed in the area of the work and a member in good standing of a Professional Engineers Association in the area of the work. Geothermal System consultant to have a minimum of five (5) years of experience in the installation of ground heat exchangers. The System consultant shall have at least three (3) system of similar type running satisfactorily and trouble fee at time of tender, who will:

    a. Provide a complete engineered geothermal field design including complete signed and stamped installation drawings.
    b. In general, consider the borehole location and header trench locations as shown on the drawings as the basis of design, as they have been coordinated to suit the project's existing trees and have been coordinated other services.
    c. Submit design documentation showing required peak heat rejection capacity, peak heat absorption capacity, yearly field heating capacity and yearly field cooling capacity will be fully met over a simulated 20-year period, using geothermal thermal conductivity data included in the tender package and provided by the design team.
    d. Design, recommend, and review all proposed mechanical work Geothermal System shop, placement and securing drawings, and sign and stamp all drawings prior to submittal for review as specified below;
    e. Supervise installation of all mechanical work for Geothermal System and, when work is complete, certify in writing that the Geothermal System work has been installed in accordance with signed, stamped and reviewed drawings;
    f. Submit copies of the Geothermal System Consultant's Letters of Assurance to the Mechanical Consultant.

4. Conform to the requirements of the architectural specifications for the project.

5. All work shall be carried out in accordance with CSA C448 Series-02 "Design and Installation of Earth Energy Systems" as amended from time to time and shall meet the requirements of the Ministry of The Environment's (MOE) regulations. The contractor must be in possession of a valid ECA permit from the MOE.

6. Refer to Volume 3 for required geothermal "Thermal Conductivity Test Report"..

7. Geothermal Contractor Qualifications

i. Ground exchanger system shall be provided by a qualified and experienced contractor with a minimum three (3) years experience in the installation of ground heat exchangers. The contractor shall have at least three (3) systems of similar type running satisfactorily and trouble free at time of tender.

ii. Contractor shall be CGC (the Canadian GeoExchange Coalition) accredited.

1.2 Examine Site and Conditions

.1 Examine site and local conditions. Examine carefully all Drawings and complete Specifications and the test drilling report to ensure that work can be satisfactorily carried out as shown. Before commencing work, examine the work of other Sections and report at once any defect or interference affecting the work, its completion or warranty.

.2 No allowance will be made later for any expense incurred through failure to make these examinations or to report discrepancies in writing.

1.3 Materials of Construction to be Avoided

.1 Specific materials of construction to be avoided in the piping system are Acrylate Rubber and ABS plastics. Contractor shall verify with the supplier of thermofluid regarding other material to be avoided in the piping system and compatibility with materials in system.

.2 Contractor to provide pipe materials, valves, fittings and joints free from any of the above materials.

.3 Prior to fabrication and installation of piping system and materials, contractor to check with supplier of thermofluid for use of proper sealant for joints.

1.4 Submittals

.1 Conform to the requirements of Division 1, General Provisions, Section 01001.

.2 Pipe Manufacturer must provide production records upon request by the engineer, resin certification documents and CSA or NSF certification documents along with the shop drawings.

.3 Submit shop drawings for both piping and fittings.

1.5 Permits, Fees and Inspections

.1 Apply and pay for all permits, inspections, licences, fees and connection charges as required. Comply with all applicable codes, regulations of all authorities having jurisdiction.

1.6 Hours of Operation

.1 Any operation involving the production of excessive noise must be carried out between the hours of 7:00 am and 7:00 pm (when site is near a residential zone or other noise sensitive area) or as stipulated in local noise ordinance.

1.7 Completion

.1 On completion of the work of this Division, all protection erected under this Division shall be removed, all damage to this work and adjoining surfaces made good, all surplus materials and debris, tools, plant and equipment provided under this Division removed from the premises and the site left clean and tidy to the Consultant's satisfaction.

1.8 As-Built Documentation

.1 Conform to requirements of Section 01 70 00.

.2 Include list of all boreholes and actual lengths of each borehole and amount of grout pumped. To be certified by installer.

.3 Boreholes shall be dimensioned from building so that every borehole can be located. Alternatively a GPS survey can be used.

1.9 Operation and Maintenance Manual

.1 On completion of the work of this Division the Contractor shall compile and deliver to the Consultant eight (8) complete Project Booklets. Each Booklet shall consist of the following:

.2 Provide Contractor contact information including, Subcontractors, equipment, suppliers and manufacturers of all equipment used in the installation indicating their full address, telephone number, fax number and name of person to be contacted for parts and service.

.3 Submittal and product data.

.4 Manufacturer's operation and maintenance instructions for same.

.5 One complete set of as-built drawings.

.6 Copies of any certificates of approval issued by authorities having jurisdiction.

.7 Copies of all tests and reports specified in this Division.

1.10 Borehole Abandonment

.1 Damaged boreholes that cannot be used must be abandoned to Ministry of the Environment requirements and standards. The Ministry shall be informed and asked to inspect the abandoned boreholes.

1.11 Warranty and Maintenance

.1 Provide a labor & material warranty for a period of one (2) year unless otherwise specified.

.2 The HDPE geothermal piping shall carry a manufacturer's warrantee against manufacturing defects for a period of 50 years or more.

1.12 Governing Authorites and Approved Agencies

.1 Abbreviations with respect to governmental authorities, testing agencies, technical societies, and approval agencies are as listed below:

ANSI	American National Standards Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AWWA	American Water Works Association
BOCA	Building Officials Code Administrators
CGC	Canadian GeoExchange Coalition
CSA	Canadian Standards Association
FM	Factory Mutual
IAO	Insurer's Advisory Organization
NBC	National Building Code
NBFU	National Board of Fire Underwriters (currently American Insurance Association)
NFPA	National Fire Protection Association
NSF	NSF International
OSHA	Occupational Safety and Health Association
TEMA	Tubular Exchanger Manufacturers Association
ULC	Underwriters' Laboratories of Canada

1.13 Quality Control

.1 The engineer will be responsible for quality control of the geothermal heat exchanger installation in accordance with C448 Series-02. The contractor must provide his full co-operation and must provide samples of material used, for testing purposes as requested by the quality control engineer from time to time.

PART 2 - PRODUCTS

2.1 Pipe

.1 Scope: This specification designated the requirements for the geothermal (ground source heat pump) pipe and fittings system, made to controlled dimensions, specifications and requirements as per ASTM D-3035 for pipe,

ASTM D-2683 for socket fusion fittings, ASTM D-3261 for butt/sidewall fusion fittings and ASTM F-1055 for electrofusion fittings.

.2 Material: All pipe and heat fused materials shall be manufactured from TR480 virgin polyethylene extrusion material in accordance with ASTM D-2513, Sections 4.1 and 4.2. The material shall maintain a 1600 psi Hydrostatic Design Basis at 73.4o F. per ASTM D-2837, and shall be listed in PPI TR4 as a PE3408 piping formulation. The material shall be a high density, polyethylene extrusion compound having a cell classification of 345434 with a UV stablizer of C, D or E as specified in ASTM D-3350 with the following exception, this material shall exhibit zero failures (F0) when tested for 192 hours under ASTM D-1693, condition C as required in ASTM D-3350.

.3 Pipe: The extruded pipe sizes and dimensions shall conform to the specifications and requirements of ASTM D-3035-93 or CSA B137.1. All piping shall be manufactured from virgin resin with allowance for on-site re-processed resin. Recycled resin must not be used.

.4 Pipe with a diameter of 50mm (2”) (nominal) or less shall be manufactured with a minimum dimension ratio of 11, except that in vertical bore applications greater than 183 meters (600’) deep, the minimum dimension ratio shall be DR 9. Pipe 75mm (3”) (nominal) and larger shall be manufactured with a minimum dimension ratio of 15.5. Schedule sizing (i.e. Sch 40) of the pipe shall not be used.

.5 Pipe used for vertical bore applications shall include a factory-fused single piece, injection molded u-bend fitting with a minimum dimension ratio of 9. U tube heat exchanger pipe shall be delivered to site pressurized with air at 68.9 kPa (10psi) min. Butt fusion joints will not be accepted.

.6 Marking: Each pipe, 50mm (2”) nominal and less, shall be permanently indent marked with the manufacturer’s name, nominal size, pressure rating, relevant ASTM standards, NSF-geothermal, CSA B137.1 and CSA C448 designation, cell classification number and date and location of manufacture. Pipe larger than 50mm (2”) nominal do not require permanent indent marking, but should be marked with the same identifying information. Coils, 50mm (2”) nominal and less, shall permanently indent marked with footage marks at 610mm (24”) intervals. Each fitting shall be identified with the manufacturer’s name, nominal size, pressure rating, relevant ASTM standard and lot number.

.7 Packaging, Handling & Storage: The pipe and fittings shall be packaged, handled and stored in accordance with pipe manufactures recommended procedures. All pipes shall be capped until ready for installation.

.8 Installation: Construction and installation shall be in compliance with CSA Standard C448 Series-02 (as amended from time to time) and any applicable local, provincial and federal regulations.

.10 Manufacturer: The pipe and fittings manufacturer shall have in place a functional quality assurance program, be ISO 9001 and CSA or NSF (Canadian) Certified.

.11 Pipe shall be listed in Canadian NSF certified products for geothermal applications.

.12 Pipe must carry either the csa or the nsf logo. No alternative test agencies accepted.

.13 Standard of Acceptance: Trinus Pipes and tubes Ltd.

2.1 Fittings

.1 Molded fittings shall be manufactured to the dimensional specifications and requirements of ASTM D-2683 for socket fittings, ASTM D-3261 for butt/sidewall fittings and ASTM F-1055 for electrofusion fittings with a minimum dimension ratio of 11. The material used in the manufacturing of the fitting shall be the same approval base resin material as the connecting pipe. Only socket fusion fittings are to be used.

.2 Standard of Acceptance: Trinus Pipes and Tubes Ltd. or Rahn Plastics fittings

PART 3 - EXECUTION

3.1 General

.1 The developer will provide all water necessary for the installation of the system.

.2 Drilling shall be performed from the existing site grade, allow for extra drilling, pipe and grout from top of final borehole elevation to existing grade. Extra pipe shall be cut 1m above top of final borehole elevation. Remaining borehole pipe shall be capped with fusion caps or heat crimped to prevent entry of foreign material.

.3 The Geothermal Contractor shall provide for the disposition of any water associated with the installation of the geothermal wells. Dispose of drill cuttings unless otherwise instructed by the owner/project manager.

.4 Excavation of trenches and final backfill and compaction will be done the this contractor.

.5 The ground heat exchanger contractor shall be responsible for backfilling and compaction of all sand backfill in trenches required for the installation of the ground heat exchanger piping and shall level backfill to 300mm (12”) (compacted thickness) of top of HDPE piping. Backfill material shall be compacted in layers no thicker than 300mm (12”). Compaction shall be to Architects Specifications but not less then 95% proctor density. Trench depth shall be as shown on the project drawings. Final fill and compaction to sub-grade will be by excavation contractor. Any damage to the ground exchanger components by others will be repaired and billed by the geothermal contractor as a change to his scope of work.

.6 Use sand as a backfill in trenches up to 300mm (12”)(Compacted thickness) above pipe. Keep sharp and hard objects (i.e. rocks, scrap iron) away from the pipe. Any

trenches improperly backfilled or where settlement occurs, shall be reopened to the required depth, refilled and properly compacted.

.7 Minimum cover for all horizontal piping shall be 900mm (3.0ft.). Horizontal piping with less cover shall be provided with 102mm (4”) thick minimum SM Blue sheet insulation just above the pipes. This insulation shall extend 610mm (2ft.) on either side of the pipes.

.8 4” rigid SM Blue insulation to protect storm, sanitary drains and water supply lines from potential freezing, when in close proximity (within 4 ft.) of the geothermal lines, shall be provided by drainage contractor.

.9 Waterproof areas where pipes penetrate floors

.10 All HDPE plastic joints must be made by socket fusion. Pipe manufacturer's recommendations shall be followed.

.11 Cap open pipe ends during construction to prevent entry to foreign material.

.12 Tracing wire, multi-strand 1.63mm (14 ga.) insulated copper wire, shall be placed for each individual 32mmØ (1.25”Ø) supply and return tracing entire route of borehole pipes from 75mm (3”) sub-manifold locations to geothermal each borehole. These wires shall be identified with the corresponding trench and borehole number. In addition yellow or orange coloured caution tape marked shall be provided to mark location of trenches. Tape shall be laid on top of final sand layer (~300mm above pipe). Tape shall be set over each trench on 600mm (24”) centers. Terminate tape at building walls.

.13 The Geothermal Contractor shall remove all borehole hole cuttings and excess material from trenching. Include all costs associated with this work.

3.2 Installation

.1 Borehole piping shall be installed as shown on the drawings.

.2 Geothermal boreholes shall be drilled 152mm (6”) diameter to accommodate two 32mm (1-1/4”) pipes with a "U" shaped bend at the bottom. Close coupled u-bends shall not be used.

.3 Pipe shall be installed into borehole immediately after drilling is completed in order to eliminate possibility of hole collapse before pipe insertion.

.4 Boreholes shall be tremie grouted immediately after pipe installation, bottom to top for the full depth of the borehole in a single and continuous operation. Add material if settlement occurs, until settlement is complete. Dedicated grouting unit shall be used for its preparation.

.5 Grout shall be thermally conductive BAROTHERM® GOLD bentonite material combined with water and dry silica sand ranging between 50 and 70 mesh as tabled. Materials in borehole column shall be replaced by this mixture after

enough water or other drilling fluid has been circulated in the annular space to clear any obstructions. Please refer to table below for grout properties.

Grout Properties Table (Metric Units)					
k W/m · °C	**Silica kg/22.7kg**	**Water liters/22.7kg**	**Slurry Yield (liters)**	**Density (SG)**	**% Solids (by weight)**
1.73	113.4	69.5	122	1.7	66.3%
Grout Properties Table (U.S. Units)					
k Btu/hr · ft · °F	**Silica lb/50-lb**	**Water gal/50-lb**	**Slurry Yield (gallons)**	**Density lb/gal**	**% Solids (by weight)**
1.0	250	18.3	32.1	14.1	66.3%

.6 Bundles of supply line and return line headers shall be run in a common trench separated by rigid insulation. Refer to detail on drawings.

.7 Assure that kinks on pipes do not occur. Accomplish this by laying the curved pipe on a hard surface with a gentle curve.

.8 All loop piping shall be sloped up towards the sub-manifold locations.

3.2 Locating Requirements

.1 Locate the ground exchanger precisely from building components. Alternatively locate each borehole by using a GPS locator and record the coordinates on as built drawings.

3.3 Pressure Testing

.1 Perform pressure testing as per following table. Provide as required all necessary equipment, piping, valves and drain connections to perform the work. Due regard shall be given to the static head at the lowest point in the loop (the burst pressure rating of the pipe shall not be exceeded).

Test Item	Test Element	Test Pressure	Test Duration
u-tubes prior to installing in borehole	water	minimum 689 kPa (100 psig)	15 minutes
u-tubes after installing in borehole and tremie-	water	minimum 689 kPa (100 psig)	1 hour

grouting			
after each runout has been assembled including connection to boreholes and prior to backfilling	water	minimum 689 kPa (100 psig)	1 hour
Stage 1 50mmØ sub-headers prior to connecting to mechanical room header prior to backfilling	water	minimum 689 kPa (100 psig)	2 hours
Stage 2 50mmØ sub-headers prior to connecting to mechanical room header prior to backfilling	water	minimum 689 kPa (100 psig) pressure drop shall not exceed 3%	minimum 12 hours

.2 If the installation is done in winter with temperatures below freezing, exposed pipe may be tested with antifreeze mix in lieu of water.

3.4 Flushing and Purging

.1 Flush piping of debris and purge of air after the completed.

.2 A portable temporary flushing/purging unit capable of maintaining the minimum flow velocity of 0.61 m/s (2 ft/sec) in all piping sections shall be used.

.3 Flushing with potable water shall be maintained until all dirt and contaminants are removed and no more dirty water appears at outlet and for 15 minutes after last air bubbles are observed leaving the system. Once completed, add ethanol antifreeze if piping is exposed to freezing, then cap for future connection.

.4 Once the ground exchanger is connected to the building system, final flushing and purging shall be the responsibility of the mechanical contractor.

3.5 System Fluid

.1 Water, 25% food grade propylene glycol and corrosion inhibitors. Final fluid fill (antifreeze and water) will be the responsibility of the mechanical contractor in accordance with CSA C448 Series-02. This Contractor will leave the geothermal heat exchanger filled with water and sealed.

3.6 System Balancing

.1 Fluid flow through geothermal ground exchanger shall be measured, balanced in accordance with original design and reported. Balancing will be the responsibility of Division 23 00 00.

.2 The Division mechanical contractor shall run system for minimum of twelve (12) hours and purge air from lines before balancing.

END OF SECTION

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PART 1 - GENERAL

1.1 General Conditions

.1 The General Conditions, Div. 1 Supplementary General Conditions, and all other Contract documents listed in the Tender shall apply to and govern all phases of the Work herein-after specified and/or shown on the drawings.

1.2 Scope of Work

.1 The listing in the Specifications and/or drawings, of any articles, materials, equipment and systems requires that this Division shall supply each item listed of the quality noted and quality required, and install all items in accordance with instructions and methods prescribed to produce the intended operation of all equipment or systems, supplying thereto all necessary labour and incidentals.

1.3 Codes and Standards

.1 Design, specifications and installation must comply with latest editions and all amendments of the following codes standards. Where conflicts in requirements occur the higher standards will apply:

.1 Electrical Safety Code;
.2 Ontario Hydro;
.3 CSA - Canadian Standards Association;
.4 EEMAC - Electrical and Electronic Manufacturers' Association of Canada Standards;
.5 NBC - National Building Code;
.6 All governing local and/or municipal requirements;
.7 ULC - Underwriter's Laboratories of Canada;
.8 CUA - Canadian Underwriter's Association.

.2 Where the supply of an item, the wiring of installation method, etc., are specified generally only, without extensive detail, this implies the item and or work shall conform with the requirements of the governing authority, viz. Hydro Inspection Department, etc.

1.4 Documents

.1 This Division of the Specification has generally been divided into Sections. It is not thereby intended to recognize, set or define limits to any sub-trade contractor or to restrict the Contractor in letting subcontracts. Neither is the Contractor relieved of responsibility for completion of Contract whether sublet or not.

1.5 Shop Drawings

.1 Submit shop drawings for, but not limited to, the following items:

.1 Lighting fixtures and lamps;
.2 Controls;
.3 Wiring Devices;
.4 Panelboards;
.5 Transformers;
.6 Fire Alarm System;
.7 Emergency System;
.8 Contactors and Motor Starters;
.9 Security System;
.10 P.A./Telephone System;
.11 Clocks;
.12 Hand Dryers;
.13 Cafetorium P.A. System.

.2 Submit ten (10) copies of all typed sheets listing manufacturer's and supplier's names, catalogue model numbers for all items.

Submit a schedule of shop drawings for approval no later than two (2) weeks after award of Contract, indicating the anticipated date of submission for review.

Assume full responsibility for submission of shop drawings. Allow minimum five (5) days; maximum three (3) weeks for processing.

The Consultant will only review shop drawings after they have been corrected by the Contractor to conform to Contract Documents and have been dated and signed by him, and bear the Contractor's stamp of approval.

.3 Submit shop drawings, showing the following:

.1 Project name;
.2 Project tag number;
.3 Manufacturer's name and model number;
.4 Supplier's name;
.5 Approval agencies;
.6 Dimensions;
.7 Electrical characteristics;
.8 Materials used in manufacture and type of finish;
.9 Time required to fabricate and deliver;
.10 All variations from Tender Documents.

The Consultant's review shall not relieve the Contractor from the responsibility of providing materials and equipment in accordance with the design intent and Contract Documents.

Circulate shop drawings to all subcontractors for their review and comments prior to submission to the Consultant.

1.5 Shop Drawings(Cont.)

.4 Drawings will be marked and action taken as follows:

	Consultant's Markings	Action by Contractor
.1	Reviewed	Proceed with work.
.2	Reviewed as Modified	Proceed in accordance with markings. Resubmit revised drawings for record.
.3	Revise and resubmit	Submit revised drawings for review before proceeding.

.5 Also conform to requirements of Supplementary General Conditions, GC-34.

1.6 Appliances

.1 Provide any extension cords, lamps and miscellaneous materials, temporarily required for carrying out work.

1.7 Correction After Completion

.1 Submit a written guarantee to Owner covering the remedy of defects in the Work at completion of Work but before issue of final certificate. This guarantee shall in no way supplant another guarantee of longer period called for on certain items or materials.

.2 Submit a similar written guarantee for one year from date of substanial performance for any part of Work accepted by Owner, before completion of whole work.

1.8 Protection of Work and Property

.1 Each trade shall protect its own and other trade's finished and unfinished work from damage, due to the carrying out of its work. Each trade shall assume responsibility for repairing damage resulting from its failure to provide such protection. Carry out such repairs in a satisfactory manner without expense to Owner.

1.10 Electrical Inspection

.1 Department of Labour certificates shall be renewed as necessary to remain in force for the guarantee period.

. 2 Furnish necessary certificates as evidence that work installed conforms with laws and regulations of authorities having jurisdiction.

1.11 Office and Storage

.1 Provide temporary office, workshop and tools and materials storage space for the work and assume responsibility for any loss or damage thereto.

1.12 Coordination

.1 Work of each trade shall be laid out so that it does not conflict with Work under other Divisions of Specification. Make good damage to Owner's property or other trade's work, caused by improper locating or carrying out of Work.

.2 Co-operate with other Trades engaged on the work to ensure that items installed under this Section are located in proper relation to other equipment with building construction and Architectural finish.

.3 Produce interference drawings and submit to Consultant for review.

1.13 Contract Drawings

.1 Drawings showing the Work are diagrammatic only. Take any information involving accurate measurements of building from Architectural Drawings or at building.

.2 The general location and route to be followed by services are indicated on Drawings.

.3 Equipment dimensions are based on the first or top named manufacturer. Dimensions of items by other listed manufacturers shall not exceed available space with necessary allowance for service and maintenance.

1.14 As-Built Drawings

.1 Conform to requirements of Section 01200 and 01700.

1.15 Continuity of Existing Services and Systems

.1 No outages shall be permitted on existing systems except at the time and during the interval specified by the Owner and by the Project Representative who may require written approval prior to power interruption. Any outage must be scheduled when the interruption causes the least interference with normal building schedules and business routines. No extra costs will be paid to the Contractor for such outages which must occur outside of regular weekly working hours.

.2 Any circuit interrupted as a result of this work shall be restored to proper operation by this Contractor as soon as possible

1.16 Workmanship

.1 Workmanship and method of installation shall conform to best standards and practice and shall be performed to approval. Work shall be performed by licensed tradesmen skilled in work to be performed.

1.17 Temporary and Trial Usage

.1 Temporary or trial usage of materials shall not be construed as evidence of acceptance of same.

.2 Permanent building electrical services and equipment may not be used for construction purposes except as otherwise directed in writing by Engineer and approved by the Owner.

.3 When permitted, permanent lighting fixtures intended for temporary lighting purposes shall be used only with temporary lamps which if fluorescent, shall be different in colour from the permanent lamps. All temporary lamps shall be removed before permanent lamps are installed. Fixtures other than two-40 watt rapid start fluorescent shall remain de-energized.

1.18 Standard of Materials

.1 Equipment items shall be standard products of approved manufacture. Identical units of equipment shall be of same manufacture. In any unit of equipment, identical component parts shall be of same manufacture, but the various component parts comprising the unit need not be of one manufacture.

.2 Materials and equipment are specifically described and named in this Specification in order to establish a standard of material and workmanship.

.3 Materials required for performance of work shall be new and the best of their respective kinds and of uniform pattern throughout work.

.4 Materials shall bear approval labels as required by Code and/or Inspection Authorities.

1.19 Painting

.1 Primary and final painting for Work, other than items specified as factory primed or finished, will be done under Finish Division 9.

1.20 Accessibility

.1 Accessibility for equipment servicing is extremely important. The Contractor shall ensure that adequate access doors are provided in each system and that adequate space is provided around the equipment for servicing. All access walkway widths to be free from any tripping hazards or overhead obstructions.

.2 Provide access for future removal and replacement of all electrical equipment without demolition or removal of adjacent equipment.

1.21 Cutting and Patching

.1 Lay out and install work in advance of other Sections. Bear all costs resulting from failing to comply with this requirement.

.2 Core drill holes in concrete walls and floors for piping where not previously sleeved. Do not use mechanical hammers or drills without prior approval in writing by Structural Engineer. Neatly patch holes to approval and where located in exterior walls above grade, make watertight. Make holes in walls below grade with due provision for pipe movement (min. 50mm clear all around), fill with 50mm thick fibreglass blanket insulation and seal watertight with mastic.

.3 See Sections relating to 'Supports and Bases' and co-ordinate this work to other Sections to prevent unnecessary cutting and patching.

1.22 Access Doors

.1 Submit list of proposed access door locations and obtain approval thereof before commencing access door installation.

.2 Submit access door shop drawings for approval as soon as possible after Award of Contract, showing size, type and exact location of access doors.

1.23 Outlet Boxes

.1 Where 100mm (4") square outlet boxes shall be installed in exposed concrete or cinder block in finished areas, the opening shall be cut to provide a close fit to boxes and covers so that edges of openings are not visible after installation of plates. Mortar shall not be used to patch up openings that are cut too large or to patch ragged edges.

1.24 Conduit Accessories, Condulets and Fittings

.1 Conduit accessories, condulets and fittings shall conform to C.S.A. Standard C22.2 No.18-1972.

1.25 Location of Outlets

.1 Location of lighting, convenience, telephone, power and communication outlets shall be subject to change, without extra cost to Owners, provided information is given prior to installation. No extra amount will be paid for extra labour and materials for relocating outlets up to 3000mm (10 feet) from their original location nor will credits be anticipated where relocation up to 3000mm (10 feet) reduces materials and labour. Other cases will be considered on their individual merits.

1.26 Lighting and Receptacle Panels

.1 After completion of wiring, type directory showing a clear description of each circuit being controlled from panel and place in metal frame inside door.

.2 Panels shall be constructed and finished in accordance with details specified in Article "Panel Trim".

1.27 Distribution Panels

.1 Provide engraved nameplates on each fused switch in accordance with details specified in Article "Equipment Identification".

.2 Panels shall be constructed and finished in accordance with details specified in Article "Panel Trim".

1.28 Electrical Work for Other Divisions

.1 The locations of starters, motors and associated equipment indicated on the drawings are approximate and diagrammatic only. Co-ordinate with the work of the Division 15 Mechanical Trade Sections to ensure proper location of equipment. The exact locations of conduit terminations at Mechanical units shall be determined from equipment manufacturer's approved shop drawings. Conduits must be installed to enter only in the locations designated by equipment manufacturers.

.2 Unless otherwise stated, the following work shall be handled by the Divisions as mentioned. Mechanical means either Plumbing and Drainage Section or Heating, Ventilation and Air Conditioning Section. All power wiring above 100 volts shall be carried out by Electrical Division, and all low voltage, below 100 volts, components shall be supplied, installed and wired by the Mechanical

Section involved. All control wiring including interlocking wiring regardless of voltage shall be done by Division 15.

ITEM	SUPPLIED BY	INSTALLED BY	CONNECTED BY
Starters, including those supplied loose as a part of packaged equipment	Electrical	Mechanical	Electrical
Disconnects (for mechanical equipment)	Mechanical	Electrical	Electrical
Electrical Unit Heaters	Electrical	Electrical	Electrical
Electric Force Flow Heaters	Electrical	Electrical	Electrical
Exhaust Fan interlock	Mechanical	Mechanical	Mechanical
Motorized Dampers	Mechanical	Mechanical	Mechanical
Low Voltage Control Wiring	Mechanical	Mechanical	Mechanical
Control Wiring	Mechanical	Mechanical	Mechanical
Components of Evaporative Fluid Cooler (see 15650)	Mechanical	Mechanical	Electrical

1.29 Examination of Site and Contract Documents

.1 Examine site and local conditions. Examine carefully all Drawings and complete Specifications to ensure that work can be satisfactorily carried out as shown. Before commencing work, examine the work of other Sections and report at once any defect or interference affecting the work, its completion or warranty. No allowance will be made later for any expense incurred through failure to make these examinations or to report any such discrepancies in writing.

.2 Unless exceptions are specifically noted at the time of Tender, the submission of a tender confirms that the Contract Documents and site conditions are accepted without qualifications.

1.30 Valuation of Changes

.1 For each change submit a complete itemized breakdown of labour and material.

.2 Only the net difference between an extra and a credit will be subject to overhead and profit mark-up.

.3 Materials shall be valued at current trade prices incorporating all discounts and labour rates in accordance with union contracts at the time of issuing Notice of Change.

.4 Also see Supplementary Conditions, GC12, Document 00800.

PART 2 - PRODUCTS

2.1 Equipment Identification

.1 Labels for feeder conduits, and cables to indicate their content shall comprise pressure sensitive tape. Labels shall be printed on plastic coated tape, 50mm x 150mm (2" x 6") size with black printing on yellow background indicating applicable voltage, i.e. 600 volts.

.2 Labels shall be as manufactured by:

W.M. Brady Co. of Canada Limited - B350
Ideal Electric Canada Ltd.

.3 Labels shall be bilingual.

2.2 Outlet Boxes

.1 Ceiling boxes shall be 100mm (4") octagon or square, complete with fittings, where required to support fixtures.

.2 Switch and receptacle boxes shall be:

.1 No. 1104, where flush mounted in wood or drywall, with stud fasteners as required.

.2 Masonry boxes in masonry walls.

.3 Where boxes are surface mounted in unfinished areas they shall be FS condulets.

.4 Tile wall covers shall be as manufactured by:

Steel City Electric Company

.5 Standard outlet boxes shall be manufactured from code gauge galvanized steel.

.6 Outlet boxes installed outside building and/or in damp locations shall be FS weatherproof type. If in direct contact with the ground they shall be made of cast iron.

.7 Provide a suitable outlet box for each light, switch, receptacle or other outlet, approved for the particular area in which it is to be installed.

.8 Support outlet boxes independently of conduit and cable.

.9 Locate outlet boxes, mounted in hung ceiling space, so they do not obstruct or interfere with the removal of lay-in ceiling tiles.

.10 Offset outlet boxes, shown back to back in partitions, horizontally to minimize noise transmission between adjacent rooms.

.11 Use gang boxes at locations where more than one device is to be mounted. Use combination boxes with suitable barriers where outlets for more than one system are shown.

.12 Use tile wall covers where 100mm (4") square outlet boxes are installed in exposed concrete or cinder block in finished areas.

.13 Flush mount boxes, panels, cabinets and electrical devices, which are installed in finished areas, and fit with suitable flush trims and doors or covers, unless specifically noted otherwise. 'Thruwall' and 'Utility' type boxes shall not be used.

.14 Use multi-gang boxes with barriers between each gang where devices served by dissimilar voltages utilize a common faceplate.

.15 Identify all electrical junction and pull boxes of different systems with paint or phase tape as follows:

120/208 volt System:	BLACK
347/600 volt System:	BLUE
Fire Alarm System:	RED
Emergency Lighting System:	ORANGE

2.3 Conduit Accessories, Condulets and Fittings

.1 Wall entrance seals shall be as manufactured by:

O.Z. Electrical Mfg. Co. Inc. - Type WSK

.2 EMT couplings shall be steel concrete tight to match connectors.

.3 Rigid galvanized steel conduit with threaded IPS fittings to be used:

.1 where noted and required by regulations
.2 where embedded in poured-in-place concrete
.3 where installed in concrete which is in contact with earth or grade.

.4 Electrical metallic tubing (EMT) may be used concealed in place of rigid conduit in dry locations subject to governing regulations. All connectors and couplings

for EMT and flexible tubing shall be forged steel complete with factory installed insulated throats. EMT may be used at Contractor's option, installed in concrete, subject to use of concrete-tight fittings. Connectors and couplings to be forged steel.

.5 Use flexible metallic conduit for connections to chain suspended and recessed fixture drops, motors, transformers and similar equipment to prevent transmission of vibration. A code-gauge green grounding conductor shall be provided for all such connections. Use 'Sealtite' conduit with Hubbell-Kellum Sealtite conduit strain relief grips for all such connections at motors.

.6 Conduit installed below grade and below concrete grade slabs shall be rigid PVC type, CSA approved as Electrical Raceway.

.7 Conduit and cables for electrical work in demountable type and drywall type partitions shall enter from above from a junction box concealed in the ceiling above and shall comprise a flexible conduit connection.

.8 Provide a separate code gauge supplementary grounding conductor run in each non-metallic conduit or duct, terminating at ground block at panelboards.

.9 Conduit fittings shall be as manufactured by:

Crouse-Hinds of Canada Ltd.
Kondu Mfg. Co. Limited
Thomas & Betts Ltd.
Killark of Canada
Efcor of Canada Ltd.

.10 Steel conduit shall be as manufactured by:

Conduits National Co. Ltd.
MBF Industries

2.4 Flashings Through Roof

.1 Provide factory fabricated seamless copper protection sleeves Telmark 'Stack-Jack' or approved equal. Co-operate with work of Roofing Section to ensure weathertight installation.

2.5 Conductors, Wires and Cables

.1 Wiring installed in conduit, unless otherwise noted, shall be 600 volt "RW 90 X-Link". However, wiring in channel back of fluorescent fixtures shall be 600 volt type GTF or TEW.

.2 Conductors used for all auxiliary systems (e.g. Fire Alarm, and the like) shall be tagged and/or colour-coded and where applicable shall agree with

manufacturer's wiring diagrams. Conductors in underfloor raceways and cable duct systems shall be stranded type. Use Electrovert 'Z-type' code markers for control conductors.

.3 Minimum wire size for power wiring shall be No. 12 AWG gauge unless specified otherwise. Control wiring shall be #14 AWG red insulation. Maximum voltage drop between furthest outlet of any circuit, when fully energized and panel to which it is connected shall not exceed two percent except for electric heating circuits which shall not exceed one percent.

.4 Number of wires indicated for lighting and power motor and motor control, alarm, signal, communication and auxiliary systems is intended to show general scheme only. The required number and types of wires shall be installed in accordance with equipment manufacturer's diagrams and requirements and with requirements of the installation, except that specification standards shall not be reduced.

.5 Wires for lighting, power etc. shall be copper.

.6 Home runs to lighting and receptacle panels which exceed 25m (75 feet) in length, shall be minimum No. 10 gauge.

.7 Conductors shall be colour coded. Conductors No. 10 gauge and smaller shall have colour impregnated into insulation at time of manufacture. Conductors size No. 8 gauge and larger may be colour coded with adhesive colour coding tape but only black insulated conductors shall be employed in this case, except for neutrals which shall be white wherever possible.

.8 Colour Coding shall be as follows:

Phase "A" - Red	Ground - Green
Phase "B" - Black	Neutral - White
Phase "C" - Blue	Control - Orange

.9 Wire shall be as manufactured by:

Canada Wire and Cable Co. Ltd.
Alcan Wire and Cable
Industrial Wire and Cable (1970) Ltd.
Phillips Cables Ltd.
Pirelli Cables Ltd.

2.6 Local Switches

.1 Local switches shall be 20 ampere, silent, A.C. type and C.S.A. listed.

.2 Local switches shall be as manufactured by:

Pass & Seymour
Harvey Hubbell of Canada Ltd.
Westinghouse Canada Ltd.- Bryant Smith & Stone Inc.

Slater Electric (Canada) Ltd.
Leviton

.3 Catalogue numbers listed below have been used for convenience only to indicate quality standards.

Type	Approved Catalogue Numbers	
	Hubbell (120 volt)	Hubbell (347 volt)
Single Pole	1221	18221
Double Pole	1222	18222
Three-Way	1223	18223
Four-Way	1224	18224

.4 Combination switches shall have neon pilot light and jewel on stainless steel plates.

.5 Local switches and receptacles shall be of the same manufacturer throughout except where a specified item is not made by that manufacturer.

.6 Provide local switches as shown and as specified.

.7 Local switches shall be located with center at a height of 1350mm (4'6") above finished floor and shall be located on lock side of door, or as shown on classroom control panel.

.8 Key operated switches shall be of the types listed above, except all key-operated switches shall be keyed-alike.

2.7 Electric Plate Finishes

.1 Switches, receptacle, telephone and other plates shall be stainless steel 18-8 chrome metal alloy, Type 302, non-magnetic. Finish brush marks shall be run in a vertical direction. For single gang plates, brush marks shall run in long direction of plate.

.2 Cover plates shall be as manufactured by:

Arrow-Hart of Canada Ltd. - #93000 Series
Harvey Hubbell of Canada Ltd. - #93000 Series
Pass & Seymour Inc. - #93000 Series
Westinghouse Canada Ltd. - Bryant - #93000 Series
Leviton - #93000 Series

2.8 Receptacles

.1 Receptacles shall be as shown and as specified. For convenience, only one or two catalogue numbers of manufacturers as follows have been shown:

Pass & Seymour Inc.
Harvey Hubbell of Canada Ltd.
Westinghouse Canada Ltd. - Bryant

.2 The receptacles listed below represent the most common configurations available and are not necessarily used on this project. Refer to Drawings for type used.

15 ampere, 120 volt, single phase grounded duplex receptacles shall be NEMA-U-ground type CSA Configuration 5-15R, as manufactured by:

Pass & Seymour - No. 5262
Hubbell - Cat. No. 5252
Westinghouse Canada Ltd. -Bryant - 5262

15 ampere, 120 volt, weatherproof receptacles shall be equal to those above but complete with gasketed cast plate and hinged covers.

.3 Combination switch, receptacle, and pilot light shall be as manufactured by:

Smith & Stone - 4-5268-10 Products

2.9 Ground Fault Circuit Interrupters

.1 Ground fault circuit interrupters (G.F.C.I.) shall be complete with receptacle, breaker, test feature and 15A-1P circuit breaker as indicated.

.2 Unit shall include a 15A ground duplex receptacle, a button to test operation of unit, current transformer and sensing mechanism, and a 15A-2P circuit breaker. Unit to be complete with suitable backbox.

.3 Unless noted otherwise, unit shall have a sensitivity of 5 mA.

.4 Install in all washrooms, outdoor locations, next to sinks and within 1500mm (5 feet) of water and as per Code requirements.

.5 Units shall be as manufactured by:

Hubbell Canada	- Cat. #GF5252
Canadian General Electric Co. Ltd.	- Cat. #TGRT-115F
Pass & Seymour Inc.	- Cat. #1591

2.10 Time Switch & Contactors

.1 Time switches, unless noted otherwise shall be single throw, double pole, 120 volt type with astronomical dial and omitting device. Time switches shall be complete with enclosures and shall be for surface mounting, unless noted otherwise.

.2 Time switches shall be as manufactured by:
Sangamo Co. Ltd.
Canadian General Electric Co. Ltd.
Tork Controls of Canada Ltd.

.3 Provide time switches as shown.

.4 Provide a suitably sized flush-mounted switch, to by-pass time switch.

.5 Contactors shall be mechanically held, electrically operated, capacity as shown on the drawings.

2.11 Safety Switches

.1 Fused or unfused disconnect or safety switches shall be Type "A" quick-make, quick-break construction with provision for padlocking switches in either "ON" or "OFF" position.

.2 Switches throughout job shall be of same manufacture.

.3 Fused switches shall have fuse clips designed for NEMA Class "J" HRC fuses and designed to reject standard N.E.C. fuses.

.4 Switches shall be as manufactured by:
Square 'D' Company (Canada) Ltd.
Westinghouse Canada Ltd.
Canadian General Electric Co. Ltd.
Schneider/Federal Ltd.
Siemens Electric

.5 Provide fused or unfused safety or disconnect switches as shown and as required.

2.12 Fuses

.1 Fuses shall be sized as shown and provide list of fuses required.

.2 Fuses shall be Form I, NEMA "J" H.R.C. current limiting type.

.3 Fuses shall be as manufactured by:
English Electric Co. Ltd.

2.13 Dimmers

.1 Dimmers for use on incandescent lamps shall be equal to Lutron, "Nova Series" complete with tungsten surge protection and white cover plate. Provide Lutron

#LDC-21C lamp debuzzing coil when dimming 150 watt "Par" or "R" lamps unless otherwise shown on drawings.

2.14 Lighting and Receptacle Panels

.1 Lighting and receptacle panels shall be surface or flush-mounting type, as shown. Surface type shall be sprinkler proof type.

.2 Panels shall be dead front type in code gauge steel enclosures. Bus work in panels shall be copper throughout.

.3 Each panel shall be complete with a directory which shall be mounted inside door in a metal frame with clear plastic cover.

.4 Panels shall have mains of voltage and capacity, and main and branch breakers and contactors, as shown on the "Lighting and Receptacle Panel Schedule". Spaces shall include necessary bus work such that Owners, at a later date, need buy only the breakers. Bus work in panels shall be copper throughout.

.5 Contactor in panel mains shall be electrically operated, mechanically held (or as shown on drawings) and shall be rated to control incandescent, fluorescent and other loads as shown. Contactors shall be mounted within panel and shall be open type. Contactors shall be complete with fuse and fuse adapter mounted and connected to line side of contactor and shall be connected to supply power to operating coil. Coil clearing contacts shall be included in contactor where a contactor is controlled by a time switch.

.6 Contactors shall be as manufactured by:

Ascolectric Ltd. - Bulletin 920 Series

.7 Where panels exceed 42 circuits, use multi-section panel with main cross-over solid bus bars. Main bus capacity of each section shall be full size to match cross-over bus.

.8 Breakers shall have bolted type connections. Two and three pole breakers shall be common trip type with a single handle, suitable for voltage applied and of same manufacture as single pole breakers. Panels shall be complete with full size breakers.

.9 Branch breakers shall be molded case type with a symmetrical interrupting capacity of 10,000 A.

.10 Where shown on the Drawings, certain breakers shall include ground fault interrupter.

.11 Panels for 347/600 volt, 3 phase, 4 wire systems, shall be complete with breakers having a symmetrical interrupting rating of 14,000 A.

.12 Panels shall be factory assembled, of the same manufacture and shall be as manufactured by one of the following:

Westinghouse Canada Ltd.
Schneider/Federal Ltd.
Square "D" Company (Canada) Ltd.
Siemens Electric

2.15 Distribution Panels

.1 Distribution panels shall be surface or flush-mounted type as shown. Panels shall be of dead front CDP type. Surface type shall be sprinkler proof type.

.2 Breakers shall be of quick-make, quick-break, bolted connection molded case type with thermal trips.

.3 Panel shall have mains capacity and branch breakers as shown. Buswork in panels shall be of copper throughout.

.4 Panel bus shall be designed to safely withstand stresses and heating imposed by minimum 50,000 amperes symmetrical fault current.

.5 Panel interiors shall be factory assembled. They shall be designed so that units are readily removable and interchangeable without modification to buswork or mounting rails.

.6 Panels shall be complete with breaker sections , spares and spaces as shown. "Spares" shall be understood to be complete breaker sections. "Spaces" shall be understood to include necessary buswork such that Owners, at a later date, need buy breaker only.

.7 Panels shall be as manufactured by:

Westinghouse Canada Ltd.
Schneider/Federal Ltd.
Square "D" Company (Canada) Ltd.
Siemens Electric

2.16 Panel Trim

.1 Panels shall be given a rust-resistant treatment to both tub and trim.

.2 Flush panels shall have concealed hinges and flush type combination lock latch. Locks shall be chrome plated. Doors shall open minimum 135 degrees. Trims shall have fasteners concealed and shall be prime coated to receive room finish paint.

.3 Surface mounted panels shall have manufacturer's standard trim complete with lock and latch.

.4 Surface mounted panel shall be finished with two coats of gray ASA No. 61.

.5 Panel locks shall be common to one key throughout project, except that main fire alarm control panel shall be keyed differently. Locks shall be those used by Lighting Panel Manufacturer.

.6 Recessed panels shall have standard flush trims.

2.17 Clocks

.1 Provide clocks as shown on drawings. Clocks shall be Simplex type 2310, 120V, round 12", complete with clock hanger type receptacle back box and tamper-proof clips to hold clock in place.

.2 Clocks for General Purpose Room shall be the same as above but 15" round complete with stainless steel guard.

2.18 Hand Dryers

.1 Nova model #180000, recessed mounted, 208V, 60HZ-2000W. Colour to be selected by Architect prior to construction.

2.19 Ladder Type Cable Tray System

.1 Ladder type cable tray system shall be Wiremold, SpecMate F Series Ladder Tray.

.2 Cable tray depth shall be 100mm (4"). Rung spacing shall be 610mm (24"). Tray width shall be 225mm (9").

.3 Provide all essential connectors, fittings and accessories to form a complete ladder type cable tray system as shown on the floor plans.

.4 Cable tray system is to be used for computer communication cables only. Cable tray shall not be used for electrical power wiring.

.5 Conduits for electrical feeders shall not be connected to any part of the cable tray system and shall be kept to a minimum of 200mm (8") clear of tray.

PART 3 - EXECUTION

3.1 Final Inspection

.1 Request in writing for a final inspection of electrical systems after:

.1 deficiencies noted during job inspections have been completed;

.2 the cleaning up is finished in every respect;

.3 record drawings are completed and approved.

3.2 Standard of Materials

.1 Install materials in strict accordance with manufacturer's recommendations.

.2 Include items of material and equipment not specifically noted on Drawings or mentioned in Specifications but which are necessary to make a complete and operating installation.

.3 Confirm capacity or ratings of equipment being provided, when based on ratings of equipment being provided under other trade Sections, before such items are purchased.

3.3 Instructions to Operator

.1 Instruct Building Operators in care, maintenance and operation of Electrical Systems and associated equipment.

3.4 Maintenance Data

.1 Compile information and prepare three Maintenance Data manuals which shall include:

.1 Manufacturer's installation, operation and maintenance instructions, replacement parts and names and addresses of suppliers, for all movable apparatus and mechanically and electrically operated items, appliances and equipment.

.2 Detailed instructions and recommended materials for cleaning, lubricating and maintenance.

.3 Chart showing any necessary seasonal adjustments to electrical apparatus and recommended minimum and maximum time intervals for inspection of all items.

.4 Lists of lamps (incandescent, fluorescent and H.I.D.) used throughout the project indicating: wattage, voltage, ordering abbreviation and/or catalogue number.

.5 List of fuses, overcurrent, overload, protective relays, etc. indicating type; size; quantity; and name of machine, motor, feeder or device protected.

.6 Supply one complete set of 'Reviewed Shop drawings' in separate hard cover binder suitably separated and labelled for owner's use.

3.5 Painting

.1 Store electrical materials and equipment such as switchboards, panels, unit substations, and luminaires in a dry, clean location and cover with polyethylene plastic to preserve factory finish.

.2 Protect exposed or free standing equipment with plastic to minimize entry of dust and dirt and marring of finished surfaces during progress of Work.

.3 Repair and finish factory finished equipment, damaged or scratched during installation, in an approved manner.

.4 Leave a quart can or a pressurized spray can of paint, as used for switchboards, with Owner for touch-up purposes.

.5 Schedule luminaires, lamps and diffusers for installation as late as possible during construction in order to minimize accumulation of dust and/or dirt on them. Clean luminaires, not acceptable because of dust and dirt, in an approved manner, dip diffusers in detergent and air dry. Wrap surface mounted and suspended luminaires, installed prior to painting and other dusty construction being completed in the area, in plastic to prevent dirt and paint from settling on them.

3.6 Cleaning, Lubrication and Adjustment

.1 Immediately prior to completion of work:

.1 Remove all dust, dirt and other foreign matter from internal surfaces of enclosed electrical apparatus and equipment.

.2 Remove all temporary protective coverings and coatings temporary labels.

.3 Clean, repair, lubricate and adjust all mechanism and movable parts of apparatus and equipment leaving it in new condition and operating properly.

.4 Balance demand loads for service and distribution feeders within 5% upon completion of work and after the building is in full operation.

.5 Refer to tender preamble.

3.7 Equipment Identification

.1 Provide nameplates on each piece of electrical equipment, namely power panels, distribution panels, lighting panels, transformers, disconnect switches, contactors, telephone panels, miscellaneous systems panels, double throw switches and automatic transfer switches.

.2 Nameplates for each electrical panel shall indicate panel designation, mains voltage and panel and circuit number from which this panel is fed.

.3 Nameplates for transformers shall indicate transformer primary and secondary voltage and transformer name and designation.

.4 Nameplates for terminal cabinets shall indicate system, and voltage and load of area served.

.5 Fasten each plate with two chrome plated screws. Lettering shall be 6mm (1/4") high for small devices such as control stations and at least 13mm (1/2") high for all other equipment. Submit a list of proposed nameplates for approval before manufacture.

.6 Identify Junction Boxes, pull boxes, cover plates, conduits and the like, provided for future extension, indicating their function; (e.g. power, fire alarm, communication).

.7 Verify room names and numbers prior to listing on nameplates and schedules.

.8 Band feeder and sub-feeder bus or conductors as above. Band main bus on lighting and power panels with tape as follows to conform to the Canadian Electrical Code.

Red - Phase A
Black - Phase B
Blue - Phase C
White - Neutral
Green - Ground
Orange - Control

.9 Identify control conductors for motors and equipment by pressure sensitive tape markers at each main terminal point and wherever they are introduced into ducts

or equipment. Schedule and chart marker numbers with corresponding machine numbers and locations and include with Record drawing.

.10 Label feeder conduits, cables and bus ducts.

3.8 Hangers and Inserts

.1 Provide necessary hangers and inserts for work of this Division.

.2 Erect hangers free of kinks and plumb; where plumb hangers are not possible, install slanted hangers in pairs in a manner to balance the load. Secure to building structure by suitable means in a manner to develop full strength of hanger.

.3 Fasten to cast-in place concrete by suitable drilled or cast-in Inserts.

.4 Fasten to structural steel using bolts or welded fasteners.

.5 Use trapeze hangers consisting of rods and unistrut where several conduits run together.

.6 Do not use wood, chain, wire lashings, strap or grappler bar hangers except where noted or detailed Percussion type fastenings (fastenings set by an explosive charge) may be used only with written permission of Engineer.

.7 Support fixtures independently of ceiling suspension systems using metal chains. Provide additional supports as required which shall be fastened to building structure steel members, joists, beams, etc., but not metal or roof decking. Material for additional supports and their installation shall comply with requirements of U.L.C.

.8 Support outlet and junction boxes independently of the conduits running to them where required by electrical code and where deemed necessary by the Engineer. Use steel angle brackets or steel rods to support fixture outlets.

.9 Surface mounted or stem suspended fixtures fastened to nonremovable ceilings, 2 hr. fire rated ceiling assemblies, or mounted between metal suspension of exposed T-grid ceilings, shall be provided with minimum of two points of attachment for each 1' x 4' luminaire using metal 'channel-bar' fastened to building structure. Attach luminaires to the 'channel-bar' by means of threaded steel rods. Channel-bar shall be adequately supported and of a construction to prevent deflection under load, as selected from manufacturer's published data and to Engineer's approval. 'Channel-bar' shall be Unistrut, Burnby, Flexibar, Cantrough or Canadian Strut Products or approved equal.

.10 Use support clips (e.g. Caddy Type IDS) for suspension of fixtures attached to exposed T-grid ceilings. Clips shall be supported directly from building structure and not from suspended ceiling system.

.11 Provide recessed fluorescent fixtures with support frames and plastering frames where applicable.

.12 Drilled fastenings to concrete shall be self-drilling concrete anchors, Phillips 'Red-Head' or approved equal. The maximum weight per fastening shall not exceed 25% of manufacturer's 'pull-out' load data.

.13 Where chain is used to support fixtures, whether they are surface mounted or suspended, the chain shall be double loop lion chain, Number 2 type or closed link type capable of supporting ten times the fixture weight. Jack chain shall not be acceptable. Chain shall be secured at both ends with bolts, fender washers, etc., no open hooks or 'S' hooks shall be allowed to support chain.

.14 Support outlet boxes, junction boxes, conduit and the like mounted on exposed steel deck roofing by means of self-tapping minimum #10 gauge screws, secured through bottom member of deck corrugation. Do not pierce top of steel deck.

.15 Recessed lighting fixtures shall have two support chains or wires from the building structure, with each chain or wire supporting two corners of the lighting fixture.

3.9 Testing

.1 Make tests of equipment and wiring at times requested.

.2 Tests shall include meggered insulation values, voltages and current readings to determine balance of panels and feeders under full load, and operation of each piece of equipment for correct operation.

.3 Supply meters, materials and personnel as required to carry out these tests.

.4 Faulty and defective equipment shall be replaced with new materials. Conductors which are found to be shorted or grounded or to have less than proper insulation resistance, shall be replaced with new conductors.

.5 Tests shall include, but are not limited to the following:

.1 Test of secondary voltage cables shall include Meggar tests to establish proper insulation resistance and phase-to-ground resistance of cables.

.2 Proper functioning of all systems.

.3 Polarity tests - to establish proper polarity connections to all sockets and receptacles.

.4 Test of system neutral to establish proper insulation resistance and isolation of neutral from ground except for required ground connection at Service.

3.10 Certification of Test

.1 When work is complete submit three copies of test results and a signed statement listing all tests that have been performed as required by specifications and manufacturer's instructions.

3.11 Free Service

.1 In addition to the guarantee covered by the General Conditions of the Contract, all equipment installed under this Division shall receive free emergency service for the full guarantee period (normal maintenance procedures not included).

3.12 Supports and Bases

.1 Electrical panels, switches or other electrical equipment shall be complete with suitable bases or mounting brackets. Install angle or channel iron supports to bear the equipment where it is shown on or in structural tile walls, or walls that are inadequate to bear the equipment.

.2 Locate raceway hangers only at joint between precast slabs, where raceways are supported from any precast slab construction, and attach hanger rods to steel plates on top of slab. Attach additional horizontal steel members to rods similar to those specified above, where raceways or equipment must be located between joints of precast slabs, and fasten hangers to the horizontal steel member. Examine Architectural and Structural Drawings to determine in which area precast flooring occurs.

.3 Support hangers, in general, from inserts in concrete construction or from building structural steel beams, using beam clamps. Provide additional angle or channel steel members, required between beams for supporting conduits, cables and bus ducts.

.4 Do not use explosive drive pins in any section of Work without obtaining prior approval.

3.13 Hangers and Inserts

.1 Provide necessary hangers and inserts for work of this Division.

.2 Erect hangers free of kinks and plumb; where plumb hangers are not possible, install slanted hangers in pairs in a manner to balance the load. Secure to building structure by suitable means in a manner to develop full strength of hanger.

.3 Fasten to cast-in place concrete by suitable drilled or cast-in Inserts.

.4 Fasten to structural steel using bolts or welded fasteners.

.5 Use trapeze hangers consisting of rods and unistrut where several conduits run together.

.6 Do not use wood, chain, wire lashings, strap or grappler bar hangers except where noted or detailed Percussion type fastenings (fastenings set by an explosive charge) may be used only with written permission of Engineer.

.7 Support fixtures independently of ceiling suspension systems. Provide additional supports as required which shall be fastened to building structure steel members, joists, beams, etc., but not metal or roof decking. Material for additional supports and their installation shall comply with requirements of U.L.C.

.8 Support outlet and junction boxes independently of the conduits running to them where required by electrical code and where deemed necessary by the Architect use steel angle brackets or steel rods to support outlets fixtures, due to weight, to the building structure.

.9 Surface mounted or stem suspended fixtures fastened to non-removable ceilings, 2 hr. fire rated ceiling assemblies, or mounted between metal suspension of exposed T-grid ceilings, shall be provided with minimum of two points of attachment for each 1' x 4' luminaire using metal 'channel-bar' fastened to building structure. Attach luminaires to the 'channel-bar' by means of threaded steel rods. Channel-bar shall be adequately supported and of a construction to prevent deflection under load, as selected from manufacturer's published data and to Architect's approval. 'Channel-bar' shall be Unistrut, Burnby, Flexibar, Cantrough or Canadian Strut Products or approved equal.

.10 Use support clips (eg. Caddy Type IDS) for suspension of fixtures attached to exposed T-grid ceilings. Clips shall be supported directly from building structure and not from suspended ceiling system.

.11 Provide recessed fluorescent fixtures with support frames and plastering frames where applicable.

.12 Drilled fastenings to concrete shall be self-drilling concrete anchors, Phillips 'Red-Head' or approved equal. The maximum weight per fastening shall not exceed 25% of manufacturer's 'pull-out' load data.

.13 Provide chains for the installation of fluorescent lighting fixtures shall be No.4 2mm (0.80") Tenso Pattern coil steel chain plated with a strength of 180 lbs. (82 kg.) as manufactured by Dominion Chain Co. Ltd. or approved equal. Where 'S' hooks are used with chain they shall be No. 6 type with open strength of 180 lbs. (82 kg). minimum. Attachment of chain at both ends of support shall develop full strength of chain.

.14 Support outlet boxes, junction boxes, conduit and the like mounted on exposed steel deck roofing by means of self-tapping minimum #10 gauge screws, secured through bottom member of deck corrugation. Do not pierce top of steel deck.

3.14 Access Doors

.1 Provide access doors for locations where equipment requiring maintenance or adjustment is "built-in". These access doors will be installed under the Division in whose work they occur. Arrange for and pay cost of access door installation.

.2 Where lay-in removable panel ceilings requiring hold down clips are used, access doors are not required but panels shall be secured with accessible hold-down clips and marked with Bildemup #6RH brass paper fasteners inserted through acoustic panel and bent over. Paint heads with blue enamel before installation.

3.15 Grounding

.1 Ground electrical equipment and wiring in accordance with Canadian Electrical Code and Local Inspection Authority's Rules and Regulations.

.2 Install grounding conductors, outside Electric Rooms in conduit and conceal where possible. Ground equipment with brass, copper or bronze bolts and connector or weld using Cadweld or Thermoweld processes.

.3 Provide grounding conductors, sized as per Code, and connect to own grounding grid.

.4 Clean exposed copper to a bright surface and finish with two coats of clear insulating varnish.

.5 Provide an exposed perimeter ground bus in Electrical room consisting of minimum 6mm x 32mm (1/4" x 1-1/4") copper, mounted 75mm (3") above floor on 12mm (1/2") waterproof fibre insulated spacers 600mm (2'-0") on centers. Provide copperweld ground rods, 3m x 20mm (10'-0" x 3/4") at the corners of Electrical Room, and connect to station equipment. Connect exposed metal work in Electrical Room to the perimeter bus with copper cable run in conduit and conceal where possible. Run cables in conduit, in a similar manner, to external grounding grid.

Provide ground grid consisting of 3 x 10'-0" x 3/4" ground rods, located outside the building and connect to grounding system in the electrical room.

.6 Provide separate ground grid (consisting of interconnected ground rods) for pad mounted transformer.

3.16 Wiring Methods

.1 Install wiring in conduit unless otherwise specified.

.2 Use thin wall conduit, up to and including 2" conduit size, for branch circuit and signal wiring in ceilings, furred spaces, and in hollow walls and partitions. Use rigid galvanized steel conduit for wiring in poured concrete, where exposed, and for conduit 2-1/2" or larger.

.3 Flexible conduit and armoured cable will be accepted in parts of building, where furred spaces above ceilings are too congested to permit conduit to be installed.

.4 Conduit shall be of sufficient size to permit easy removal of conductors at any time. Conduit sizes, where shown, are minimum and shall not be reduced. Do not bend conduit over sharp objects. Improperly formed bends and running threads will not be accepted. Do not use bends and fittings together.

.5 Run conduits and cables in finished areas concealed, above finished ceiling, under floors, in walls and in partitions. Run conduit and cables in unfinished areas, such as fan rooms and penthouses, exposed and installed at right angles or parallel to building lines, accurate in line and level.

.6 Runs of conduit and cables, where shown, are indicated only by general location and routing. Install conduits and cables so as to provide maximum head room and to interfere as little as possible with use of spaces through which they pass. They shall be installed as close to building structure as possible, so that, where concealed, necessary furring can be kept to a minimum.

.7 Arrange conduits, installed in suspended ceilings, to provide minimum interference with removal of tiles.

.8 Conduit and cables for electrical work shall not be installed on, or connected to the corridor cable tray. Conduit and cables shall be located minimum 150mm (6”) from the corridor cable tray.

3.17 Branch Circuit Wiring & Feeder Cables

.1 Provide branch circuit wiring, conduits and feeders as required for Lighting, Power and Auxiliary Systems Separate conduit systems shall be provided for feeder, lighting and power systems, for exit light system and auxiliary communication systems (e.g. Fire Alarm and Bell Telephone).

3.18 Conduit Accessories, Condulets and Fittings

.1 Conceal conduits and wiring except where noted. Run exposed conduits parallel to building lines and to other conduits. Provide every empty conduit with a fish wire 3mm (1/8") polypropylene rope) and identify to designate its functions (Power, P.A., Telephone, Fire Alarm and the like).

.2 Fasten every conduit to structure by means of approved conduit clamps or clips. Wire lashing is not acceptable.

.3 Where conduit is installed in concrete slabs, obtain general approval, prior to commencing the work, on both maximum dimension and cross-overs which may be used therein. Comply with requirements of CSA Standard No. A23.3 Paragraph 5.17.

.4 Install conduits in such a manner as to conserve head room and interfere as little as possible with free use of space through which they pass. Obtain approval for routing of same. Keep conduits at least 150mm (6") clear of heating pipes, flues and other high temperature work.

.5 Run conduit exposed in mechanical equipment rooms, electrical rooms, and fan rooms after mechanical and other equipment is completed. Install fixtures, outlets, starters, etc. to clear and to suit application.

.6 Conduit installed at the roof level of exposed structures shall be run tight to roof deck, above purlins and beams.

.7 Install junction boxes or cable anchor boxes wherever necessary for proper pulling or anchoring of cables. Install so as to be accessible after building is completed and set to come within finished lines of building.

.8 Terminate rigid conduit entering boxes or enclosures with nylon insulated steel concrete tight connectors.

.9 Terminate flexible conduit entering boxes or enclosures with nylon insulated steel connectors.

.10 Install wall entrance seals where conduits pass through exterior walls below grade.

3.19 Holes and Drilling

.1 Pneumatic hammers and percussion drills are prohibited.

.2 Where not sleeved, make holes through concrete walls and floors by core-drill only.

.3 Seal holes and sleeves through floors to serve as water dam.

.4 Comply with requirements of CSA Standard No. A23.3 Paragraph 5-17.

3.20 Conductors, Wires and Cables

.1 Neatly train circuit wiring in cabinets, panels, pull boxes and junction boxes and hold with nylon cable ties.

.2 Splice wire, up to and including No. 6 gauge, with nylon insulated expandable spring type connectors. Splice large conductors using split-bolt or compression type connections wrapped with PVC tape.

.3 Where colour coding tape is utilized, it shall be applied for a minimum of 50mm (2") at terminations, junction and pull boxes and condulet fittings. Do not paint conductors under any condition. Colour coding shall also apply to bussing in panels and bus duct.

.4 Armoured or sheathed cables may be used only for wiring within demountable and dry wall type partitions and if additionally specified or detailed; however it shall not be directly buried in or below concrete slabs.

3.21 Electric Plate Finishes

.1 Do not install plates until final painting of room or area is completed. Remove protective covering.

3.22 Receptacles

.1 Provide receptacles as shown and as specified.

.2 Do not mount receptacles directly on a column, unless column has been furred, to avoid breaking fire barrier.

.3 Unless noted otherwise, outlets for plug-in clocks shall be located 500mm (18") below ceiling line.

.4 Mount receptacles horizontally, 500mm (1'-6") to center above finished floor, or 250mm (9") above counter top where shown at counters or benches, unless noted otherwise.

.5 Connect receptacle grounding terminal to the outlet box with an insulated green strap.

3.23 Fuses

.1 Provide a complete set of fuses in each fusible device supplied under this Division.

3.24 Dimmers

.1 Provide dimmers as shown. Where more than one dimmer is shown in the same location, mount dimmers in individual backboxes.

3.25 Lighting and Receptacle Panels

.1 Provide lighting and receptacle panels, surface or flush-mounting type, as shown.

.2 Provide locking bars on non-switched circuits where panels are used for switching lighting circuits.

.3 Provide panelboards as scheduled which shall include the following features:

.1 flush or surface trim as noted
.2 self-closing springs where located in corridors
.3 concealed hinges
.4 combination catch and lock semi-flush tumbler type all keyed alike
.5 adjustable self-positioning trims
.6 sufficient wiring space for specified cables and conduits. Except as noted panelboard depth shall not be less than 4-1/2" for panelboards with feeder conduits up to 2". Depths shall be increased accordingly for larger feeders.
.7 plain trims not displaying any names or Symbols. 'Vault' type handles shall not be used except in unfinished areas.
.8 insulated neutral block

3.26 Panel Trim

.1 Co-ordinate panel finish with Room Finish Schedule.

.2 Deliver ten (10) duplicate keys for panel locks to Owner.

3.27 Panel Mounting Height

.1 Mount electrical panels, where possible, with top of trim at uniform height of 1900mm (6') or to match door heads or to suit tile/block layout.

3.28 Excavation and Backfilling

.1 Perform necessary excavation and backfilling, as required, for the installation of conduits, and cables. Excavation, pumping, supports, backfilling etc., shall be in accordance with Section 2A.

3.29 Electrical Work for Other Divisions

.1 Provide power wiring for mechanical equipment, all necessary wiring and connections including wiring and installation of starters, thermostats, aquastats, speed controllers and time switches controlling equipment.

.2 Where motor starters, switches, and the like, are grouped together, a suitable 19mm (3/4") thick plywood panelboard shall be provided to which all such equipment shall be secured. Provide all necessary angle iron supports for support of panelboard and paint entire assembly with two coats of enamel (ASA-61 grey).

.3 Provide interlocking between motorized dampers and starters for all exhaust fans.

.4 Refer to Mechanical Equipment Schedule on the Drawings for further Detail.

END OF SECTION

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PART 1 - GENERAL

1.1 General Requirements

.1 Comply with the General conditions of the Contract, Supplementary General Conditions, Requirements of Division 1, Common Work Results -Electrical Section 26-05-01

1.2 Work Included

.1 Work to be done under this Section shall include furnishing of labour, materials, and equipment required for installation, testing and putting into proper operation complete Electrical systems as shown, as specified and as otherwise required. Complete systems shall be left ready for continuous and efficient satisfactory operation.

PART 2 - PRODUCTS

2.1 Telephone, TV and Computer Cabling Conduit System

.1 Provide a complete interconnecting system of empty conduits, boxes, ducts, pull boxes, back boxes, other raceways and outlets for the enclosure of telephone, cable tv and data and CCTV. The equipment i.e. speakers, amplifiers, and associated components and wiring shall be included.

.2 Horizontally mount outlet boxes, unless noted otherwise 450mm (18") center above floor. In mechanical equipment area, mount at 1350mm (54").

.3 Verify exact position of outlets to suit furniture layout.

.4 Fish conduit clear blockages and clean out outlet and pull boxes at completion of installation. Leave conduit free of water or excess moisture. Install No. 12 gauge 3 mm galvanized soft iron pull wire, or 3mm (1/8") nylon pull cord continuously from outlet to outlet through conduit and fasten at each box.

.5 Conduit shall have not more than two 90^{o} or equivalent bends and 30m (100 feet) between outlets or pull boxes and bending radius shall not be less than 10 times the conduit diameter. Conduit ends to be identified with grey paint.

.6 Back boxes for speakers in walls and ceilings shall be included as part of conduit system.

.7 Connect all cabling outlets with 3/4" minimum size.

.8 Telephone and computer cabling outlets and cover plates shall be as specified under 'Outlet Boxes' and cover plates.

.9 Provide a 3/4" conduit run from the main telephone back board to the electrical service ground for ground conductor by Bell Canada.

.10 Provide telephone line (1/2" C) to have the capability for outside communication from the following:

.1 Building Management System
.2 Elevator
.3 Computer Cabling System
.4 Intrusion Alarm/CCTV System

.11 Conduit sizes for computer outlets shall be minimum 3/4".

2.2 Pull Boxes

.1 A pull box shall be placed in conduit runs where:

.1 The length is over 100' (30m), or
.2 There are more than two 90-degree bends.

.2 Pull boxes shall be constructed of code gauge steel and shall have a rust resistant finish.

.3 In all instances pull boxes shall be placed in straight sections of conduit run and shall NOT be used in lieu of a bend. Corresponding ends of the conduit are to be aligned with each other. Conduit fittings shall not be used in place of pull boxes and/or conduit bends.

.4 Pull boxes shall be placed in a readily accessible location.

.5 Pull box locations shall be identified on the As Built Drawings.

.6 Pull boxes shall be labelled on the exposed exterior.

.7 Pull box sizes shall be as follows:

Size of Conduit:	Size of Pull Box			For each additional conduit increase width:
	Width	Length	Depth	
1" (25mm)	4" (100mm)	16" (406mm)	2" (50mm)	2" (50mm)
2" (50mm)	8" (200mm)	36" (915mm)	5" (127mm)	5" (127mm)
3" (75mm)	12" (300mm)	48" (1220mm)	6" (150mm)	6" (150mm)
4" (100mm)	15" (380mm)	60" (1500mm)	8" (200mm)	8" (200mm)

2.2 Conduit

.1 All conduits shall be thin wall EMT, reamed and bushed at both ends.

.2 Flexible metal conduit shall not be used for the installation of voice and data cabling.

.3 PVC conduit, unless poured in floor slab, shall not be used for the installation of voice and data cabling.

.4 Conduit runs shall be a maximum of 100' (30m) in length with a maximum of two 90 degree bends between pull points, unless otherwise specified.

.5 The inside radius of a bend in a conduit shall not be less than:

.1 Six times the internal diameter when the conduit is less than 2” (50mm) in diameter, or

.2 Ten times the internal diameter when the conduit is larger than 2” (50mm) in diameter.

.6 A pull cord or fish tape shall be installed in all conduits. Conduits shall be identified and labelled at both ends; tags shall identify start and finish of conduit runs.

PART 3 - EXECUTION

3.1 Conduit Installation

.1 Back to back outlet boxes shall be offset 12” (300mm) apart.

.2 Where wall outlets (for telephone and/or data cabling) are indicated in walls that do not protrude to the finished ceiling, utilize chase sections of wall for routing of conduits. Provide continuous raceways to outlets.

.3 Outlet boxes shall be placed at the same height from finished floor level as adjacent electrical duplex receptacles.

.4 Where wall outlets are indicated for telephone and/or data cabling, provide ¾” (19mm) EMT conduit with 4” x 4” x 2½” (100mm x 100mm x 64mm) outlet boxes with single outlet reducer plates from telephone closet to drop locations on floors as indicated on Drawings.

.5 All conduits entering a main computer room or LAN room (unless otherwise stipulated) will protrude into the area from 1 to 2” (25-50mm) without a bend.

.6 Where possible, conduit runs shall follow building grid lines.

.7 The cable distribution system conduits be bonded together at the electrical room and bonded to the telecommunications bus bar within the rooms using a No. 6 awg green jacketed stranded copper ground wire.

END OF SECTION

1 GENERAL

1.1 SECTION INCLUDES

.1 Digital Metering System (DMS) to collect data on major end-use of electricity, water and thermal energy (If any). Data will be integrated with Digital Metering System (DMS) and/or accessible by operations team, accounting, M&V consultant, using a web-based energy management and/or billing software (as required).

.2 The DMS can be scaled to include other utility metering. DMS can also be used for energy management and Measurement & Verification (M&V) purposes.

1.2 References

.1 Specification Section 21 05 01 Mechanical General Requirements

.2 Specification Division 23 09 23 – Building Automation System

.3 Specification Section 26 05 01 - Common Work Results – Electrical

.4 City of Toronto: Building Automation System (BAS) Information

.5 City of Toronto Cabling and Security Information

1.3 Related Work

.1 Specification Section 01 91 17 General Measurement & Verification (M&V) System

.2 Specification Section 23 21 14 Thermal Energy/BTU Meter

.3 Specification Section 23 05 11 M&V for Net Zero Energy Building

1.4 Standards

.1 Except as noted by governing codes and by the Contract Documents, comply with the applicable provisions and recommendations of the Canadian Electrical Manufacturer's Association CSA and Measurement Canada.

.2 Approved by Consumer and Corporate Affairs Canada (CCAC) and certification for legal sub-metering.

.3 Listed by the Underwriters Laboratory Inc., Standard (UNUCNL file E124377), 1 and FCC Part 15, Subpart. J. FCC Class A is required for commercial installations. The system shall be approved by Industry and Science Canada of Measurement Canada AE0763, AE0763 Rev 1, AE019AE-97-0028, AE0818.

1.5 Description of Work

.1 Provide complete, working, computer and microprocessor based CSA approved Energy and Power Measurement enabling Digital Metering System including but not limited to high density, multi-tenant electrical meters to measure and display voltage, current, frequency and time, and calculate and display Peak kW demand, totalized kWh, Instantaneous kW demand, Power Factor, ampere, kVA, kVA, kVAr and kVArh. This DMS will break down and track Electricity, Energy and Water measurements of the building. The DMS will be used to achieve the Zero Emission target for this facility.

.2 The DMS price will include all costs associated with the co-ordination of system installation, material supply, commissioning, installation verification, and customer training during the entire period of construction and system start-up.

.3 The total number of electrical meters to be monitored by the DMS shall be as shown on the electrical single line drawing.

.4 The total number of mechanical metering points to be monitored by the DMS shall be as shown on the mechanical drawings.

.5 The electrical contractor will provide all labour, equipment, materials and services and install all interconnecting wire and conduit required for the Supplier's and/or Owner's digital metering system(DMS).

.6 Provide current transformers (CTs) and potential transformers (PTs) as required by meters.

.7 System to include required inputs/outputs, contacts, RS232/RS 485/Ethernet interface for communications to remote printer, LAN or building automation system (BAS), current transformers, power feed, potential transformers and control wiring as required.

.8 Electrical metering to be suitable for operation on 120/208 VAC and 600 VAC. Refer to single line diagram.

.9 The DMS supplier is responsible for integration of pulse output water meters, specification confirmed by Mechanical Engineer and supplied by mechanical contractor.

.10 An LCD/LED display screen to be provided on each metering unit.

.11 The DMS Supplier will provide a detailed installation manual, which recognizes all applicable codes and requires final electrical as-built documentation.

.12 All meters to be installed in locations as shown on drawings. Mount in locations, connect, and test for proper operation. Comply with manufacturer's installation instructions.

1.6 **Submittals**

.1 Submit dimensioned drawings and manufacturers' data of the DMS components including but not limited to digital meter, pulse data logger, network controller, meter enclosure

.2 Submit shop drawings in accordance with 26 05 01 - Common Work Results – Electrical & 21 05 01 Mechanical General Requirements for:

.1 Interconnecting wiring diagram for the completely installed DMS.

.2 Data sheets for each system component.

.3 Operation and Maintenance manual.

.4 Information on selected reporting software

.3 Shop drawings must be submitted to M&V Consultant for approval. Any deficiencies in the shop drawings must be resolved.

.4 Submit shop drawings and manufacturer's data for the component items shown and specified under this section of the specification.

.5 Do not supply any equipment to this project prior to shop drawing review by the Consultant. Shop drawings shall be stamped and signed prior to submittal.

.6 Submit a project specific one-line diagram of the proposed system configuration for review.

.7 After shop drawing review, the Approved Drawings will be issued to the Electrical and Mechanical for installation.

.8 At the completion of the Project, As-Built Drawings will be submitted by the DMS Supplier, who will prepare a complete manufacturer's manual including all As-Built Wiring Diagrams.

1.7 **Commissioning & Training**

.1 DMS includes complete supply, installation, connection, testing, commissioning to manufacturer's instructions and recommendations to suit specific project requirements and site conditions

.2 Perform standard factory testing and submit copy of system installation, detailed testing, start-up, verification and commissioning reports to Consultant for review

.3 Be present to assist during third party testing (If required)

.4 After completion of the system testing, the Manufacturer shall conduct training of the Owner's operating and maintenance staff. Training will include both hardware items and computerized system operation.

.5 Prepare a meter functional test reporting template in consultation with the commissioning agent and successful meter vendor and fill out and sign after successful completion. A sample template is attached in appendix B.

.6 Manufacturer's trained technician to perform onsite training of each user (including the provision of user guides) prior to project completion to ensure that users are properly trained in the operation and maintenances of system.

.7 Provide instructions on system operating and maintenance.

.8 For any tenant billing meters, Measurement Canada Seals to be affixed to each field-metering panel and shown to final inspection authority and Consultant.

.9 CSA/ESA approvals and panel stickers to be visible on each field panel and enclosure

2 PRODUCTS

2.1 MATERIALS

.1 All meters, pulse data collectors, enclosures, network controllers and other control devices must be completely factory-calibrated, pre-assembled and pre-wired by the manufacturer of these devices and contain all necessary components to provide a complete and operating system within the intent of this specification.

.2 The digital metering system is to comprise the following components as further detailed herein: central computer, network controller, data line bus, floor meters and pulse data recorders, and meter enclosures.

.3 The installation of all the above noted material/equipment shall be completed by Division 26 (Electrical) and Division 22 (Plumbing) /23 (Mechanical/HVAC) in accordance with manufacturer's recommendations.

2.2 SYSTEM WORKSTATION

.1 The central computer is an IBM Compatible PC. The system is fully menu driven to provide ease of operation with a minimum of training.

.2 The central computer is complete with power supply, main frame board, non-volatile memory, separate moveable keyboard, mouse, interface cards, internal modem, cabling colour monitor, latest DOS and Windows based software, complete with licensing and the following:

.1 Intel Pentium 4, 3.0 GHz

.2 Windows XP Professional operating system with:

.3 Remote communications software

.3 USB ports a 48X speed CD-RW/DVD Combination Drive, and a

.1 500 gigabyte hard drive.

.2 2 gigabytes of memory (SDRAM).

.3 128 megabyte VGA video card.

.4 56K Flex 1V90 modem.

.4 The desk top type colour monitor shall be as follows:

.1 Minimum 19-inch colour LCD screen.

.5 Provide building program module, with non-volatile memory, so that program elements shall not be lost in the event of power failure, regardless of power failure duration.

.6 Provide central computer auxiliary function components as follows:

.1 Telephone interface module for direct code communication via the regular touchtone telephone system.

2.3 COMMUNICATIONS / NETWORKING COMPONENTS

.1 The DMS Tender price will include the necessary hardware, software and technical labour to connect the system to the owner's enterprise network or Internet.

.2 As per system manufacturer's instructions using shielded twisted pairs cable interconnecting components to Central Computer, following recognized industry standard requirements for installation of a multi-drop linear communications (network) trunk cable.

.3 The owner shall provide a connection to the Internet or the owner's Intranet. The owner shall pay any monthly access charges for connection.

.4 The owner will establish a previously and mutually agreed-upon electronic means to allow the M&V consultant to access the DMS data remotely for Measurement and Verification purposes.

.5 The system should be Programmable to adjust Automatic daylight savings (enabled or disabled).

.6 To enable the meters to communicate to the central monitoring software, CAT5 – 10BaseT Ethernet shall be run to each meter enclosure.

.7 Routers or other required networking components shall be provided according to Owner's standard.

2.4 MONITORING AND REPORTING SOFTWARE

.1 The software shall be capable of being configured and commissioned by local contractor as well as trained factory personnel.

.2 Shall have a simplified user interface for system operation.

.3 A real-time power and energy monitoring software shall be provided that will perform the following functions:

.1 Monitor all devices simultaneously with a graphical interface.

.2 Store all the data in a database for open connectivity

.3 Software shall store all meter measurements (meter pulses, demand (kW), energy (kWh) and usage (cubic meters, BTU's, etc.)) in the Workstation described in 2.5 in comma separated variable (.CSV) file format. Meters are to be read every 15 minutes (or at least hourly interval).

.4 Software shall store measurement for a period of no less than 36-months and as required by owner, measured from the date of substantial occupancy. Data will be required and must be stored for the entire duration of the M&V Monitoring period

.4 Provide reports based on time-of use or block energy consumption. Default reports shall be supplied with the software.

.5 Be a client-server application that will support multiple clients and web-browser clients so that anyone on the network can view meter data in real-time.

.6 Require no proprietary network communication hardware

.7 Support any combination of the following communication protocols directly to devices or data logger; Modbus RTU; Modbus TCP; Serial or TCP/IP; OPC is optional.

.8 Provide technical support and the first year of a software assurance contract.

.9 System to include communications interface compatible with BAS. Provide OPC Client or OPC Server or equivalent interface device as an option to integrate with other applications such as building automation systems (BAS), if required by Owner.

.10 Software shall have the ability to export data into Reporting Applications (e.g. Web, Excel and notepad).

.11 Software shall store measurement for a period of no less than 36-months, measured from the date of substantial occupancy. Data will be required and must be stored for the entire duration of the M&V period.

.12 Contractor shall supply enough device licenses per the requirements of monitoring application.

2.5 OUTPUT FILE FORMAT & STORAGE

.1 Provide a Windows™ based simplified user interface for system operation.

.2 Software shall be provided, capable of accomplishing the following functions:

.3 Data shall be recorded every 15 minutes (or at least hourly interval).

.4 Data shall be provided in comma separated value (.CSV) files.

.5 Each row in the output file shall represent a successive sample time.

.6 Include a time stamp for each line in the file.

.7 Separate each field by a single comma character.

.8 Each required monitoring point shall contain a unique and understandable identifier.

.9 Each required monitoring point shall contain a unique and understandable column.

.10 All output files are to follow the format shown in Appendix B as closely as possible.

.11 All recorded data is to be stored on the centralized data warehouse

.12 Provide a sample output data file a minimum of 1 month prior to building occupancy.

.13 Provide data files to the Owner and M&V consultant in electronic format.

.14 All meters in the system must be capable of reporting hourly, daily, monthly and annual energy use

2.6 DATA STORAGE & LOGGING REQUIREMENTS

.1 System shall be capable of storing data for a minimum of 250 DMS points (where power and energy measurements are equivalent to one point) for period of no less than 36-months.

2.7 DIGITAL METERING SYSTEM COMPONENTS

.1 The Central sub-metering system includes a computer based electronic utilities sub-metering system or equivalent high density multi-tenant digital utility grade central sub-metering system as specified herein, as shown on drawings and as required. System is to include sub-metering data collection and communications with a Central PC compatible computer and billing software. System is to be capable of handling up to 2000 sub-metering points.

.2 System includes but is not limited to following:

.1 Electronic Field Panels or Energy monitoring pod (EMP)

.2 Current transducers (CT)

.3 Step down current transformers (SDCT)

.4 Potential transformers (PT)

.5 Meter Interface Devices (MID)

.6 Pulse data recorder/Profiler

.7 System workstation

.8 System software and central terminal

.9 Network interface Cards

.10 Wiring in conduit and mounting hardware;

.11 Local governing authority approvals and licenses

2.8 ELECTRONIC FIELD PANELS

.1 All sub metering system panels and enclosures will be NEMA 2 or NEMA 12, CSA approved, sprinkler proof and suitable for the environment.

.2 All electronic field panels will be supplied in enclosures suitable for surface wall mounting and shall be complete with knockouts for conduit entry.

.3 All components should come assembled from the factory.

.4 Contain a crystal based clock for the accurate calculation of kWh and demand intervals

.5 Have a unique individual address.

.6 Contain a non-volatile memory.

.7 Be tamper-proof.

.8 be complete with automatic self-test and diagnostic features

.9 Be designed to retrieve information from field devices up to 2000 feet away.

.10 Be equipped with terminal blocks to accommodate necessary connections for current transducers, potential transformers and communication cables. For larger step-down current transformers, terminal blocks to be complete with shorting connections.

.11 Be bench verified and sealed by Measurement Canada for legalized sub-metering

.12 Provide connections for local interrogation of the unit utilizing a laptop computer.

.13 Allow Measurement Canada Approved field panel electronics to be fully removable without disconnecting any electrical terminations.

2.9 PULSE DATA RECORDER /PULSE TOTALIZER (PROFILER)

.1 Units shall:

.1 Be capable of counting pulse inputs from eight (8) independent sources such as BTU, water and electricity meters at up to 10 pulses per second (10 Hz).

.2 Date, time stamp and store up to 30-days of 15-minute utilities interval data for all 8 channels.

.3 Be designed to communicate on Modbus, RS-422 or RS-485 Local Area Network or standalone through an on board dial up modem, Ethernet or wireless Ethernet 802.11b/g interface by a PC running digital metering software to retrieve interval data.

2.10 ENERGY MONITORING PODS (EMP)

.1 Energy monitoring pods will come equipped with terminal blocks to accommodate all necessary connections for current transducers, potential transformers and communication cables.

.2 Units shall measure and transmit kWh energy consumption and present and peak kW, KVA demand.

2.11 FIELD METERS

.1 Shall be able to measure demand (KW), energy consumption (KWh), and thermal energy consumption (kWh).

.2 Shall be equipped with a pulse output and visual read out.

.3 Power supply requirements: Sel*f-powered*

.4 Shall be suitable for flow rate, pressure and temperature, and pipe size required for the mechanical system operation.

.5 The DMS will include all electrical meters, all thermal energy/BTU meters data.

.6 Electrical Meters

.1 Solid state, electronic, multi-measurement, polyphase meters, Measurement Canada approved and as follows:

.1 Electrical meters shall be provided by Division 26 (Electrical).

.2 Voltage rating: 347/600V 3ph 4w or 600v 3ph 3w

.3 Operating frequency: 60 Hz

.4 Power factor range: 0.5 to 1.0 lead/lag

.5 ± 0.2 accuracy device capable of displaying a wide range of register information as well as complying with requirements of ANSI C12.20: 1997 for Class 0.2 meters. (i.e., +/- 0.2% of 100% registration at 1.0 p.f., 1% to 100% load. It shall meet Measurement Canada accuracy requirements.

.6 Operating Temperature: -40 deg. C to +55 deg. C

.7 analogue-to-digital conversion and measurement processing;

.8 register, load-profile, real-time clock and communications processing;

.9 input and output board for pulse accumulation or event notification;

.10 five (5) measurement levels;

.11 upgradable firmware;

.12 error and event logging;

.13 flexible configuration for various metering applications;

.14 auto ranging power supply;

.15 register data and program information are retained in non-volatile memory in event of a power failure;

.16 liquid Crystal Display (LCD) that is programmable by user;

.17 energy measurements and Calculations: Wh, VARh, VAh, A2h, V2h, Ah and Vh;

.18 demand measurements: instantaneous values updated every second; maximum, present, previous, projected, cumulative, continuous cumulative and coincident demand values;

.19 Power Quality

.1 Voltage Quality e.g., phase to phase ground event detection, sag & swells, voltage & current imbalances, interruptions

.2 Harmonics e.g., THD

.20 pulse output and inputs; coordinate and confirm requirements with mechanical meter vendor(s)

.21 PF (average/minimum/instantaneous);

.22 RS232/RS485 and Ethernet communications;

.23 factory programmed to provide custom requirements of Owner to suit specific onsite applications;

.24 jaws and sockets as required;

.25 CT's/PT's as required;

.26 auxiliary outputs for monitoring connection to BAS (if required by owner); coordinate and confirm requirements with BAS vendor

.27 Communications cable from meters to DMS computer location shall be provided by Division 26 (Electrical).

.28 All electrical meters, including the main incoming service meters, shall be inter connected by a network connected to the DMS computer.

.29 Provide interface equipment as required to connect the electrical meters to the DMS computer.

.3 Thermal Energy/BTU Meters (See Details in Section 23 21 14)

.1 Thermal Energy/BTU meters shall be provided by Division 23 (Mechanical)

.2 Thermal Energy/BTU meters shall be a "True" energy meters capable of measuring flow rates from flow sensors as well as measuring supply and return temperatures from the two temperature sensors and computing energy consumption using the field level energy computer.

.3 Thermal Energy/BTU meters shall conform with Canadian Standards Association (CSA) C900 Heat Meter Standards or the European Committee for Standardization (CEN) Standard EN 1434.

.4 Communications cable from meters to DMS computer location shall be provided by Division 26 (Electrical).

.5 All Thermal Energy/BTU meters shall be inter connected by a network connected to the DMS computer.

.6 Provide interface equipment as required to connect the thermal energy/BTU meters to the DMS computer.

2.12 CURRENT TRANSFORMER

.4 Provide current transducers sized to accommodate the following electrical service sizes:

.1 100 amps

.2 200 amps

.3 400 amps

.5 For services larger than 400 amperes, provide step-down current transformers, each with a 5-ampere secondary will be provided with the required interface to the sub-metering system. A meter interface device shall expedite the meter commissioning without tools or the need for a power shutdown.

.6 Equip current transducers sized at 400 amps or smaller with pre-wired leads, three (3) metres in length.

2.13 POTENTIAL TRANSFORMER

.7 Provide PT's that are suitable for voltage ratings required for the electrical system operation.

.8 Provide factory assembled PT's and mount in separate enclosures complete with electrical disconnects and fuses.

2.14 ACCEPTABLE MANUFACTURER

.9 Carma Industries

.10 QMC Metering Solutions

.11 Or approved equivalent – all equivalents are subject to the M&V consultant's and Electrical Engineer's sole discretion.

3 EXECUTION

3.1 INSTALLATION

.1 The installation of the metering equipment shall be performed by licensed electricians, under the direct supervision of factory trained personnel.

.2 Install meters as indicated on drawings.

.3 Division 22(Plumbing)/23 (Mechanical) contractor is responsible for installing water check meters capable of integration into the DMS network and equipped with visual read out.

.4 Division 26 (Electrical) is responsible for providing a connection from the water check meters to the digital metering system location.

.5 Division 26 (Electrical) is responsible for installing electric meters capable of integration into the DMS network.

.6 Division 26 (Electrical) to coordinate with Division 22(Plumbing)/23 (Mechanical) contractor for the installation of all the meter interconnections to the DMS. All wiring shall be completed by Division 26 as per specifications. All wiring will be done in accordance with Canadian National Electric Code standards and regulations, and in conjunction with the local Electrical Safety Association office.

.7 Provide work in accordance with system manufacturer's instructions and requirements. Include for provision of following as required:

.1 Conduit for communications trunk cable and CT and PT leads;

.2 Fuses and test blocks;

.3 Connectors, fasteners and junction boxes for conduit and connectors for cable splices;

.4 Shielded twisted-pair cable for communications trunk cable;

.5 Shielded, twisted-pair cable for each CT or PT lead extensions (CTs and PTs are supplied with 3 m (10') leads from factory);

.6 Enclosures for field mounting and housing of PTs, fuses, test-blocks and interposing transducers;

.7 PT fuses and fuse blocks in order to disconnect PTs from live electrical services.

.8 Install communications trunk cable between network devices and central computer.

.9 Terminate communications LAN as per installation diagrams. Manufacturer's technician to make LAN connections at central computer.

.10 Provide 120 V grounded power for system components.

.11 Mount components away from vibration and threat of water damage.

.12 Mount PTs and connect to proper phase as per system wiring charts.

.13 Install CTs on phases corresponding to assigned PTs, as per system wiring charts.

.14 Pre-inspect, measure physical spacing, and install step-down current transformers and 5 amp interposing transducers required for main electrical services over 400 Amps.

.15 Supply and install shorting terminals with each step-down current transformer.

.16 Ensure that white dot on CTs faces toward power source and that CT/PT leads are connected to sensor boards according to lead colours specified on wiring charts.

.17 Ground CT/PT lead extension shields in accordance with manufacturer's instructions.

.18 Provide details of physical locations of PTs and CTs in Building and identify power sources for 120 V grounded power supplied, in as-built documentation.

.19 Ensure that CTs and PTs are accessible to Measurement Canada Inspection and Re-verification Personnel.

.20 Comply with requirements identified in specification, manufacturer's installation manual, Measurement Canada's Provisional Specification: PS-E-04-E.

.21 Comply with manufacturer's maximum wiring distance limitations between system components.

.22 Ensure proper size and colour code of wiring according to manufacturer's recommendations. All wiring shall be CSA approved and rated for 600V for low voltage conditions and 300V for extra low voltage conditions. Communication wiring shall be installed in twisted pairs to prevent interference from outside sources.

.23 All meters must be powered from dedicated auxiliary power supply; and not to be powered from the PTs.

.24 All current transformers will be installed with shorting switches so meters can be removed without high voltage electrical hazard.

.25 Arrange for manufacturer's technician to inspect, test, programme, verify, certify and commission system after installation is complete.

.26 Interface Digital Metering System to Mechanical Division`s BAS, if required by Owner. Provide required interface cards, software programming, wiring in conduit and coordination with BAS contractor to ensure proper and complete integration.

.27 When installing CT's/PT's, provide installation in a neat manner with CT's/PT's rigidly supported independent of cable being monitored. Secure connection cabling and label each component. Comply with manufacturer's instructions regarding CT's/PT's installations.

.28 Coordinate connections to main distribution switchboard CT's with manufacturer of switchboards.

.29 Ground and bond components as per local electrical code requirements. Refer also to requirements of grounding and bonding article.

.30 Additionally, refer to testing, coordination and verification requirements in Section entitled Electrical Work Analysis and Testing and include applicable requirements.

.31 Ensure that all meters are accessible with identification tags visible, serial numbers facing outward, for installation and inspection purposes by Operations and Maintenance personnel.

.32 Neatly secure exposed communication wire in enclosures and meter ends with approved supports or ties.

.33 Size and colour code wiring according to manufacturer's recommendations. All wiring shall be CSA approved and rated for 600V for low voltage conditions and 300V for extra low voltage conditions. Communication wiring shall be installed in twisted pairs to prevent interference from outside sources.

.34 All current transformers will be installed with shorting switches so meters can be removed without high voltage electrical hazard.

3.2 CALIBRATION AND MAINTENANCE SERVICE

.1 All meters, sensors and associated instrumentations shall be factory calibrated. Provide factory shop test calibration records/calibration certificates of all meters and sensors from the meter manufacturer.

.2 Sensors and metering equipment shall be selected based in part on the ease of calibration and the ability to hold calibration. An attractive solution is the selection of metering equipment and sensors that are self-calibration, if possible. Otherwise, all meters and sensors must be installed in such a way as to facilitate periodic calibration without interruption of system operations.

.3 Setup meters according to manufacturer's instructions.

.4 Commission the system to the satisfaction of the Measurement and Verification consultant and demonstrate the proper functioning of the system.

.5 Demonstrate and confirm that the all meter data physically recorded on the meter itself are the same readings integrated, trend-logged and archived on the Digital Metering System with proper time stamp, unit of measurement, correct meter ID, at 15-minute's interval and archived on the historical database for at least 15-months

.6 Provide a 3-hour training session to the owner's staff and Measurement and Verification consultant.

.7 Provide Measurement & Verification consultant with remote web-access to the system.

.8 Typical system architecture: The typical system architecture for a DMS is included in Appendix A for reference purposes.

.9 Meters and sensors must be installed in such a way as to facilitate periodic calibration without interruption of system operations. Frequency of calibration is per manufacturer requirement. On-going calibration of owner's meters and sensors is the responsibility of the owner.

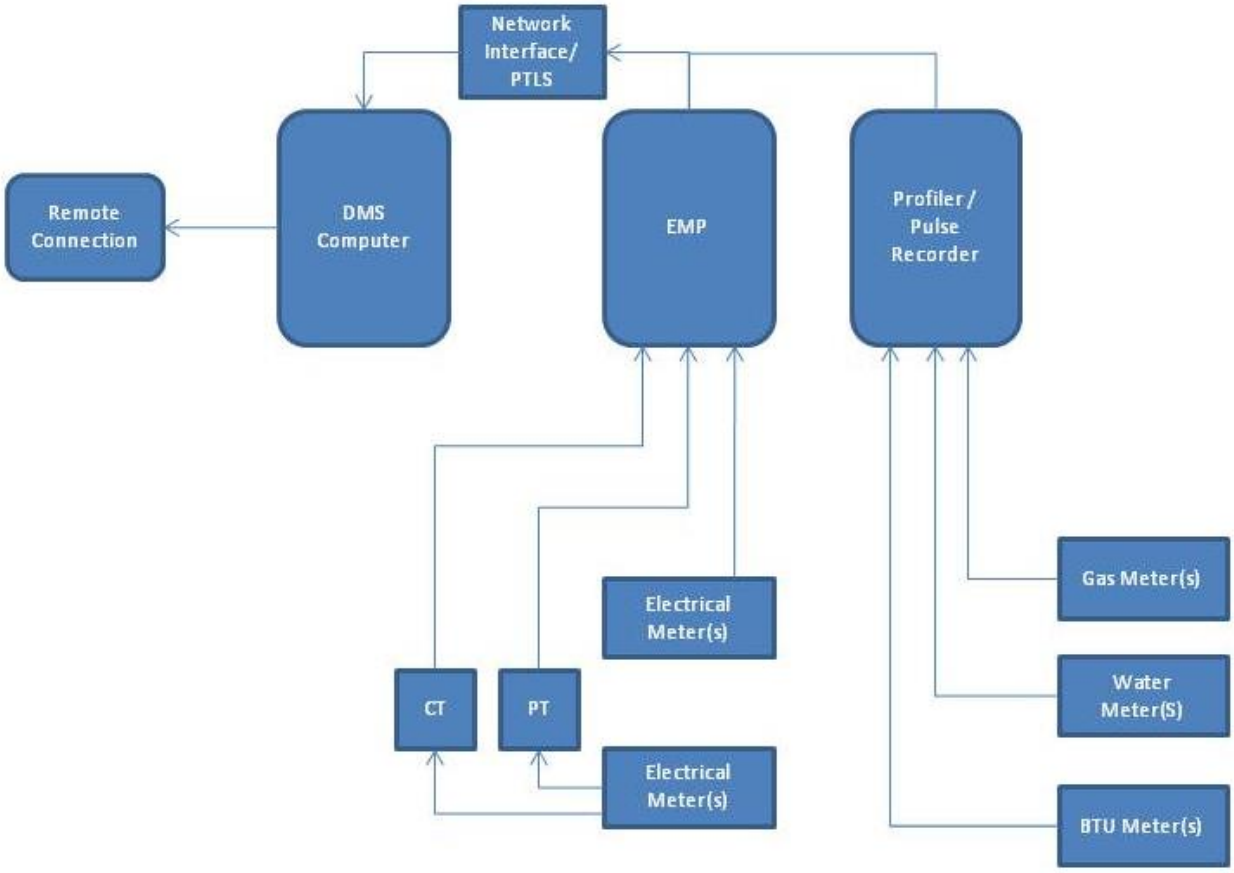
3.3 WARRANTY

.1 All equipment shall be free from defect in materials and workmanship under normal use and service for the period of twelve (12) months from the date of substantial completion.

.2 All equipment will be verified by a factory-trained technician and certified for its Revenue Class accuracy.

.3 A certificate shall be issued on final completion to confirm that the system is operating according to specifications.

26 09 13 - APPENDIX A: SYSTEM ARCHITECTURE



NOTES:

- Schematic diagram indicates the typical components that make up a typical Digital Metering System installation.
- PTs and CTs measure voltage and current (respectively), allowing EMP's to calculate electricity consumption.
- Third Party Electricity, Water and BTU (heating energy) meters are integrated into the system by Profiler/ Pulse Recorder through pulse outputs.
- DMS Computer collects data/meter readings from the EMP's and Profiler/Pulse Recorders on the network. This can be either onsite or at a remote location.
- Remote access to the system can be made through a vast number of methods, including: Ethernet (WAN /Internet/VPN), telephone line and more.

26 09 13 - APPENDIX B

SAMPLE M&V OUTPUT FILE FOR ELECTRICAL METERING

OUTPUT WHEN VIEWED IN EXCEL

Date / Time	kWh	kW	kVA
8/29/2008 1:00	14027.17	7.5	0.3
8/29/2008 1:15	14026.2	8.1	0.8
8/29/2008 1:30	14023.2	7.3	1.0
8/29/2008 1:45	14021.4	5.3	1.0
8/29/2008 2:00	14020.0	3.5	1.0
8/29/2008 2:15	14019.1	2.4	0.9
8/29/2008 2:30	14018.5	1.9	0.8

OUTPUT WHEN VIEWED IN NOTEPAD

Date / Time, kWh, kW, kVA

8/29/2008 1:00, 14027.1, 7.5, 0.3

8/29/2008 1:15, 14026.2, 8.1, 0.8

8/29/2008 1:30, 14023.2, 7.3, 1.0

SAMPLE M&V OUTPUT FILE for Totalized Thermal Energy Meter Data

Date / Time	Flow Rate L/S	Supply Hydronic Fluid Temperature °C	Return Hydronic Fluid Temperature °C	Totalized Thermal Energy Consumption kWh
8/29/2008 1:00pm	14027.17	150.21	107.51	1.25
8/29/2008 1:15pm	14045.21	165.21	108.11	2.50
8/29/2008 1:30pm	14073.21	185.21	109.31	3.51
8/29/2008 1:45pm	14091.41	205.21	101.31	4.52
8/29/2008 2:00pm	14120.01	215.25	111.51	5.53
8/29/2008 2:15pm	14149.11	235.54	121.41	6.54
8/29/2008 2:30pm	14458.51	245.23	14.91	7.50

26 09 13- APPENDIX B: Sample Meter Functional Test Form

67 - TYPICAL ELECTRICAL METERS

PROJECT INFORMATION

Project:	TBD
Project No:	TBD
Report Date:	TBD
Author:	TBD
Email:	TBD
Tel:	TBD

Testing Log

Date	Description of Testing and Participants

EQUIPMENT INCLUDED IN TESTING & SIGN-OFF

Testing Log

Equip. TAG	Description
	Electrical Meters

Sign-off

Name	Company	Signature	Date

This functional performance checklist requires sign-off from the General Contractor, Controls Contractor, and Mechanical Contractor and Commissioning Agent. By signing, the respective party indicates that they are satisfied with the results of the testing and the overall operation of the system.

	ITEMS	PASS/FAIL	COMMENTS	
	PRE-TESTING REQUIREMENTS			
1	Approved shop drawing(s) and shop drawing review report(s) of all Electrical meters and DMS/ECMS. (except the main incoming Electric meter supplied and installed by local Electric Utility Provider)			
2	Shop test certificates of all Electric meters from the meter manufacturer. (Exempted main incoming Electric meter supplied and installed by local Electric Utility provider)			
3	Confirm that all Electric meters are shown on DMS/ECMS graphics and accurately displayed.			
4	Signed calibration/commissioning certificate submitted by Electrical contractor.			
5	Confirm that installed meter accuracy is consistent with the approved shop drawing			
	METERING AND MONITORING DATA VERIFICATION			
1	Verify that DMS/EMCS monitors all meters, and data is trended. Logged and archived.			
2	Note time stamp, units of measurement, data interval and data archiving period.			
3	Note the CT ratio, PT ratio, communication protocol, IP address			

4	Verify that the Device/Object ID are provided for each meter for electrical data							
	FUNCTIONAL TESTING TABLE							
#	METER ID	DESCRIPTION	SERIAL# & ESA#	LOCATION	UNITS	INTERVAL	TRENDING	LOGGING
1								
2								
3								
4								
5								
6								

64 - TYPICAL THERMAL ENERGY/BTU METERS

PROJECT INFORMATION

Project:	TBD
Project No:	TBD
Report Date:	TBD
Author:	TBD
Email:	TBD
Tel:	TBD

Testing Log

Date	Description of Testing and Participants

EQUIPMENT INCLUDED IN TESTING & SIGN-OFF

Testing Log

Equip. TAG	Description
	Thermal Energy/BTU Meters

Sign-off

Name	Company	Signature	Date

This functional performance checklist requires sign-off from the General Contractor, Controls Contractor, and Mechanical Contractor and Commissioning Agent. By signing, the respective party indicates that they are satisfied with the results of the testing and the overall operation of the system.

	ITEMS	PASS/FAIL	COMMENTS	
	PRE-TESTING REQUIREMENTS			
1	Approved shop drawing(s) and shop drawing review report(s) of all BTU meters and DMS.			
2	Shop test certificates of all BTU meters from the meter manufacturer.			
3	Confirm that all BTU/Steam Meters are shown on DMS graphics and accurately displayed.			
4	Signed calibration/commissioning certificate submitted by mechanical / DMS contractor.			
5	Confirm that installed meter accuracy is consistent with the approved shop drawing			
6	Confirm that installed meter turndown ratio is consistent with the approved shop drawing			
	METERING AND MONITORING DATA VERIFICATION			
	Metering:			
1	Verify that DMS monitors all meters, and data is trended. Logged and archived.			
2	Note time stamp, units of measurement, data interval and data archiving period.			

3	Note the multiplier/Pulse ratio and communication protocol.							
	FUNCTIONAL TESTING TABLE							
#	**METER ID**	**DESCRIPTION**	**SERIAL# & CRN#**	**LOCATION**	**UNITS**	**INTERVAL**	**TRENDING**	**LOGGING**
1								
2								
3								
4								

END OF SECTION

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PART 1 - GENERAL

1.1 General Conditions

.1 Comply with general conditions of the Contract, supplementary general conditions requirements of Division 1 and the requirements of Section 26 05 01.

1.2 Work Included

.1 The Work to be done under this Contact shall include design, manufacture, fabrication, testing, supply delivery to site, commissioning and guarantee of Electrical Distribution equipment. Equipment to be provided shall include items listed in schedule and as specified herein.

1.3 Definitions

.1 The following abbreviations shall apply in referring to the source of Specifications listed.

ASTM	The American Society for Testing Materials
CEC	Canadian Electrical Code including Ontario Amendments
EEMAC	Electric and Electronic Manufacturers Association of Canada
CSA	Canadian Standards Association
NEMA	National Electrical Manufacturers Association
IEC	International Electro-Technical Commission

.2 Whenever a Specification number is quoted, it shall be deemed to refer to the latest amendment or revision at the date of the Tender and which is hereby made a part of the Contract as if it has been written in full herein.

1.4 Electrical Service

.1 Incoming service to the building is 120/208 volt three phase, 4 wire, 60 hZ.

1.5 Design

.1 The standards set by the various bodies having jurisdiction over the Work shall apply and it shall be the Manufacturer's responsibility to obtain all necessary approvals and to design the equipment in accordance with the applicable standards of CSA, NEMA, and of Ontario Hydro.

.2 The Manufacturer shall carry out at no additional cost to the Owner all additional tests which are required to obtain Hydro and/or CSA approval.

.3 Shop Drawings shall be submitted to show the following information:

.1 equipment layouts;

.2 general arrangement and outline drawings schematic diagrams for power and control;
.3 wiring interconnection diagrams;
.4 equipment mounting details;
.5 terminal block layout and location details.

.4 At the request of the Engineer, supporting data shall be submitted to verify the design concept. Review by the Engineer does not in any way relieve the Manufacturer of responsibility for the adequacy of the design or the satisfactory performance of the equipment as specified.

1.6 Service Entrance Switchboard

.1 Where future breakers or spaces are indicated, bus, stationary elements, breakers, control and metering wiring shall be supplied in such a manner that, at a future date, Owner need buy breaker element only. Main bus and switchboard shall be drilled and plated and have provision for future extension of additional vertical cells at end of switchboard.

1.7 Drawings and Specifications

.1 Drawings and Specifications shall be mutually complimentary and shall be read together. In case of conflict between General Conditions and Specifications the maximum required conditions shall govern.

.2 Specifications and Drawings are intended to cover complete Service and Distribution Equipment. It is not the intent to describe or show every detail and it shall be agreed that the Manufacturer provide all work and material required to provide equipment according to the requirements and intent of the Specifications and Drawings.

.3 Specifications and Drawings are not guaranteed to be free of discrepancies and the Owner and/or Engineer will not be responsible for the absence of any detail the Manufacturer may require or for any special work, equipment, material or labour which may be found necessary as the work progresses.

.4 It shall be specifically understood that the omission of any Drawing or Schedule, or reference thereto, or any part of item from any Drawing or Schedule, or from the specification, which is required to make the equipment provided complete and operational for successful performance of the functions for which it is intended, shall not relieve the Manufacturers from providing the required items or parts.

.5 Any discrepancies shall be submitted to the Engineer for his instructions.

1.8 Design and Shop Drawings

.1 The Manufacturer shall be responsible for the design of the Distribution Equipment and shall prepare from the Contract Documents and any instructions the Engineer

may issue, complete Drawings and Schedules of material and equipment intended for inclusion in the Contract.

.2 The Manufacturer shall submit for review shop drawings of the type required for the work.

.3 Shop drawings will be reviewed by the Architect and returned to the Manufacturer marked '***REVIEWED***'; '***REVIEWED AS MODIFIED***', or '***REVISE AND RESUBMIT***'. Shop drawings noted '***REVISE AND RESUBMIT***' shall be corrected and re-submitted.

.4 No equipment shall be delivered to the job site unless the Manufacturer has received a '***REVIEWED***' OR '***REVIEWED AS MODIFIED***' copy of the pertinent shop Drawing.

1.9 Dry Type Transformers

.1 Dry type transformers shall conform to CSA Standard C9-M1977, 'Dry Type Transformers'.

1.10 System Co-Ordination and Verification

.1 Prepare a detailed co-ordination study of the electrical system and test, adjust and verify that the settings of protective devices comply with the requirements established in the approved issue of the co-ordination curves. The work described herein shall be performed by an approved, recognized company with an established reputation and trained personnel and using approved and recently calibrated testing equipment. The study and associated report and the record of 'as left' test results shall be certified by a registered professional engineer.

.2 This certification shall include assurance for the following items:

.1 that the protective devices on the service entrance co-ordinate with the Supply Authority's upstream protective devices;

.2 that the protective devices within the parameters of the study conform to the results of the study;

.3 that the equipment has been tested and performs as per the settings of the approved co-ordination curves;

.4 that the 'as left' condition of the protective devices correspond to the record documents.

.3 The co-ordination study shall be submitted in a formal report document as a 'shop drawing'. It shall optimize the setting and selection of protective devices. It shall also identify areas of deviation and note areas of acceptable industry practice.

.4 The firm selected for the testing and verification shall supervise this work of the Contractor. The documentation of testing and adjusting of protective devices shall be in an approved format and bound in a Data Book.

.5 The organization selected for the System Co-ordination and Verification shall be the same as the one selected for all other factory and field testing. Completed studies and reports shall be submitted simultaneously to the Engineer as well as part of the requirements of Article 'Data Book'.

.6 The co-ordination study shall include:

.1 the protective devices on Supply Authority's system upstream from the service entrance;
.2 main switchboard equipment;
.3 largest protective devices on power and distribution panels and motor control centers.

.7 Factory witness testing shall include:

.1 BIL test on high voltage cables;
.2 compliance with IPCEA;
.3 BIL test on high voltage switchgear;
.4 BIL tests on main transformer(s).

PART 2 - PRODUCTS

2.1 Service Entrance Switchboard

.1 Switchboard shall be a dead-front, sprinkler proof, copper bus bars, free-standing assembly not requiring any rear access and suitable for mounting against a wall.

.2 Equipment shall be designed, factory assembled and tested in accordance with latest applicable EEMAC, NEMA, CSA and ANSI Standards including NEMA Publication SG-5.

.3 Coloured phase designations for all phases shall suit CSA, NEMA and Supply Authority standards. Refer to Article 'Equipment Identification'.

.4 Switchboard and components shall be manufactured by:

Cuttler Hammer
Square D
Siemens Electric
Schneider/Federal

2.2 Electrical Service

.1 Main protective device shall consist of a moulded case, Westinghouse, Series C MD frame complete with digitrip, 120/208V, 600A - 3P. Branch breakers shall be series C and as follows: 100A-FD frame; 200A-JD; 400A-KD; 600A-LD.

.2 Utility Metering

.1 Current and potential transformers for Utility Metering shall be in accordance with requirements of Supply Authority.

.2 Equipment manufacturer shall submit complete metering details for approval to Utility and obtain their approval prior to manufacture.

.3 Compartment housing utility metering transformers shall be suitable for pad locking by Utility.

.3 Metering and Instruments

.1 Provide Cuttler Hammer IQ-DP400, complete with all required hardware and software in order to communicate with device with a personal computer.

.2 Output characteristic shall be compatible with the BMS System. Co-ordinate with Section 15900.

.4 Construction

.1 Construction features to be included shall be:

.1 free-standing, rigid, dead-front enclosure;
.2 hinged and formed doors, louvred as required;
.3 bolted-on rear doors;
.4 two channels across bottom of each section to permit rolling or jacking of board;
.5 channel or angle across top of each section for hoisting purposes;
.6 two channels, to be grouted into floor, for leveling purposes, for full length of switchboard
.7 removable top plates;
.8 phase collection and supervision of necessary bolts nuts, and washers for bus duct connection;
.9 plated hardware;
.10 main buswork, 3 phase, 4 wire F.C.N., extending through all sections rated to match main breaker or transformer rating and braced to withstand stresses resulting from short circuit current of maximum system fault equal to interrupting rating of main breaker combination.

.2 Provision of vertical fire retardant and non-hydro-scopic barriers between vertical sections from bottom to top of switchboard and from front face to back of switchboard. Barriers to be sealed to prevent passage of ionized gases between vertical sections.

.3 Finish equipment as follows:

.1 basic rust-inhibiting metal process;
.2 exterior and interior in light grey ASA 61;
.3 interior in white.

.4 A quart of touch-up or several pressurized spray cans shall be supplied to touch-up small areas marred during installation.

2.3 Underground Duct Bank

.1 Ducts shall consist of CSA approved Type II pipe, in sizes as shown and encased in a concrete mixture, using screened 13mm maximum water washed gravel. Concrete shall be ready mixed concrete from an approved supplier. Concrete shall have 17.2 MPa compressive strength at twenty-eight (28) days. Bends and offsets shall be minimum 915mm radius. Suitable factory made spacers, of cast concrete or plastic, at 1.220m maximum intervals, shall maintain a clear spacing between ducts for the concrete.

.2 Contractor shall include in the scope of work all site service work shown on the drawings including any work shown in the easements. **Only connection charges** are included in the cash allowances.

PART 3 - EXECUTION

3.1 Electrical Service

.1 Provide complete electrical service as shown on the drawings and as further described here.

3.2 Service Entrance Switchboard

.1 Provide nameplates as specified in Article 'Equipment Identification'.

.2 Submit co-ordination curves for approval as specified in Article 'Protection System Co-ordination'.

.3 Contractor shall not commence final fabrication or erection of equipment until receipt of:

.1 'reviewed' or 'reviewed as modified' shop drawings from Engineer.

.4 Contractor shall review line and load side equipment connected to switchboard, as well as equipment enclosed and provide trip devices to co-ordinate with line side and load side equipment. Allowance will not be made, after Contract award, to change trip devices to provide satisfactory co-ordination.

.5 Factory Test and Inspection

.1 Test shall be performed, after completion of assembly in factory, in accordance with NEMA and EEMAC Specifications. These test shall include i-pot testing operation of breakers operation of relays meters and switches.

.2 Each circuit breaker shall have a load applied sufficient to test the overcurrent devices on breaker and to prove that trip unit and breaker function satisfactorily. Completed switchboard shall be connected to power

supply to operate electrically operated devices to prove that they are wired correctly, that contacts make and break and that devices perform satisfactorily before shipment of switchboard.

.3 Racking in and out of breakers and manual operation of equipment shall be tested to prove that items work freely.

.4 Certified copies of standard production tests shall be submitted upon request.

.5 Provide switchboard as shown and as specified.

.6 Set equipment on pad assembled shipping breaks and level equipment; bolt to pad.

.7 Provide incoming and outgoing power connections, torque all connections as required.

.8 Ground equipment to perimeter, ground bus, as required by Code.

.9 Touch up equipment areas marred in transit.

.10 Thoroughly check out equipment and arrange for demonstration to Owner.

3.3 On-Site Testing

.1 Conduct an acceptance test in presence of and to satisfaction of Engineer after completion of installation, but before substation is permanently put into service.

.2 Test shall include operation of breakers manually and electrically reacting in and out and checking that meters and relays function properly. Correct defects at no additional cost to Owner. Replace defective equipment immediately with new factory equipment.

.3 In addition to above, include work associated with field testing, cleaning and calibration of relays and trip devices in Tender cost.

3.4 System Co-Ordination and Verification

.1 Include the cost of this work in tender price.

3.5 Underground Duct Bank

.1 Provide reinforced concrete encased underground ducts as shown on the drawing.

.2 The duct run shall consist of parallel ducts. These ducts shall have an internal diameter of 100mm and shall be terminated with bell fittings at each end unless otherwise specified.

.3 The duct lengths shall be joined together with an approved coupling to provide a sound and watertight joint. The joints in adjacent ducts shall be staggered by at least 200mm.

.4 The ducts shall be laid with a spacing of 150mm center to center, both horizontally and vertically. Spacers shall be plastic or masonry. Wooden spacers shall not be used. Two spacers per 3.0m of conduit shall be used.

.5 The top surface of the duct bank shall be at least 1.0m below the finished grade.

.6 Spacers shall be installed within 610mm on both sides of each coupling used.

.7 The ducts shall have an even slope in one direction of not less than 75mm in 30.5m to provide drainage. The slope should be towards the street.

.8 The ducts shall be type II. These ducts shall comply with C.S.A. Standards C22.2 Numbers 134, 135 and B196.1 - 1972 respectively.

The ducts shall be encased with 17.2MPa grade concrete with a minimum cover of 75mm on 3 sides. The concrete shall be worked below and between pipes to produce a homogeneous mass.

.9 The duct run shall be reinforced. Reinforcing steel bars 16mm diameter shall be laid longitudinally along the trench with 100mm lateral spacing and 50mm above the base of the concrete.

An overlap of 610mm on the reinforcing bars shall be provided. The duct runs shall also be reinforced at building entry with the bars being embedded in the walls.

.10 The Contractor shall apply to Local Hydro Inspection Department 48 hours before digging the trench. The Contractors will then schedule construction and pouring inspections with the Inspection Department.

.11 When complete, the ducts shall be clear, waterproof and free from obstructions and the ends plugged with standard plastic duct plugs to prevent the ingress of moisture and dirt. The ducts shall be tested for clearance with 95mm mandrel in the presence of a local Hydro representative. A non-metallic, non-deteriorating rope (10mm = diameter of rope) of minimum five hundred pound breaking strength shall be installed in each duct.

.12 The ducts shall be left projecting (minimum 25mm) from their concrete envelope in staggered pattern. They shall be equipped with suitable couplings and plugged until the joints are made. The face of the concrete envelope shall be left rough to key with the extension envelope and 16mm diameter steel reinforcing bars 1.8m in length shall be encased longitudinally in the envelope, 50mm inside the perimeter of the bank at 100mm centers along sides and bottom of the bank. The rods shall project 900mm from the concrete to anchor firmly into the concrete of the extension when the latter is poured.

END OF SECTION

1 General

1.1 **SECTION INCLUDES**

.1 Supply all labour, materials, tools and equipment required to design, supply and install all solar photovoltaic panels, solar thermal panels and battery energy storage systems in accordance with the full intent of the drawings and the Technical Specifications including separate meter(s) and ancillary metering, monitoring equipment and weather station.

.2 Commissioning scope: Systems and/or subsystems commissioned in accordance with technical sections, including but not limited to following:

.1 All equipment related to new photovoltaic power generating system, including photovoltaic panels, combiner boxes, inverter, meters, all wiring and cables and grounding and bonding.

1.2 **REFERENCES**

.1 CEC, Clean Energy Council.

.2 CSA, Canadian Standards Association.

.3 IEC 61215, Crystalline Silicon Terrestrial Photovoltaic (PV) Modules Design Qualification and Type Approval.

.4 IEC 61730, Photovoltaic Module Safety Qualification.

.5 NEC, National Energy Commission.

.6 UL 1703, Standard for Flat-Plate Photovoltaic Modules and Panels.

1.3 **DESIGN REQUIREMENTS**

.1 System performance criteria:

.1 Total system capacity to be min 100kWdc.
.2 Total system capacity to be max. 80kWac.
.3 AC System output to be min. 112,000 kWhr/a.
.4 Total thermal capacity to be min. 123MBTU ($123x10^6$ BTU) annually
.5 System dimensions cannot exceed area for solar panels shown on the drawings.
.6 Panel system to be supported on beams provided by others, shown on Contract Drawing. All additional required supports to be by Contractor. Supporting members provided by the subcontractor to be arranged in an orderly fashion and present a neat and clean appearance.
.7 Equipment including inverters, transformers, monitoring systems batteries to be located as per architectural drawings.
.8 The system to de design to operate in the following modes: net metering, and user enabled peak shaving with the electrical grid, and critical load backup without the grid.
.9 The system shall provide the following monitoring capability.

.10 Battery to be 100kWh. The battery system maximum power output to be 50KW.
.11 All components to meet requirements of authorities having jurisdiction.

.2 System Control:
.1 The solar PV & energy storage system shall have the capability to release energy to reduce peak demand of the site through real time energy monitoring of site load and utilize a smart supervisory control system that allows the owner to control the energy flow of solar PV, grid, storage, and load via remote programming that will include but not limited to::
.1 Start/stop times when to release energy from battery.
.2 Amount of power & energy to be released.
.3 Minimum storage capacity to retain for backup.
.4 When to charge battery and charge at what power level.

.3 Solar photovoltaic panels:
.1 All photovoltaic panels shall be tested and listed by a recognized laboratory or laboratories.
.2 Certifications shall include:
.1 UL 1703.
.2 IEC 61730.
.3 IEC 61215.
.4 CSA and CEC.
.3 System shall be rated for fire per fire class C.

.4 Electrical requirement:
.1 System shall meet a minimum power output of 165W/sq m of panel. This shall be defined as the Wp nameplate rating divided by the gross area of the panel.
.2 Panels shall have a maximum temperature coefficient of power of -0.45%/°C.
.3 Panel modules must have internal by-pass diodes to minimize impact of shading on the solar panel. The shading of one module shall not render the entire panel non-operational during the shading event.

.5 Mechanical requirement:
.1 The rooftop loading shall not exceed the structural loading limits as defined by a third party structural engineer licensed to practice in Ontario.
.2 No holes or other penetrations are permitted through the sealing layer of the roof unless agreed to by the Owner.
.3 The roof surface underneath the panels shall be visible for inspection after panels are installed, and must not be damaged during installation.
.4 Roof drainage shall not be blocked by panels or panel mounts.
.5 The system must be able to withstand winds in accordance to the latest building code requirements.
.6 Equipment must be able to support 2,400 Pa snow load.
.7 All equipment must withstand an operating and storage temperature range of -40°C to +85°C.

.6 Accessibility:

.1 Product shall be installed on the racking system with the requirement that the solar panels be removable from below.

.2 Elevated truss systems shall provide sufficient clearance from the roof surface for roofing contractors to perform roof repairs or replacements in the future.

1.4 SUBMITTALS

.1 Product data:

.1 Submit copies of manufacturer's Product data in accordance with Section 01 33 00 indicating:

.1 Preparation instructions and recommendations.
.2 Storage and handling requirements and recommendations.
.3 Installation methods and data for each part of the proposed system.
.4 Manufacturer detailed test and commissioning procedures.
.5 Safety Data Sheets for the Battery Energy Storage System.

.2 Shop drawings:

.1 Submit shop drawings in accordance with Section 01 33 00 indicating:

.1 Provide wiring diagrams for photovoltaic array, battery energy storage system and interconnecting hardware.
.2 Show connection and location of equipment.
.3 General arrangement showing terminal points, instrumentation test connections.
.4 Clearances for operation, maintenance, servicing, cleaning.
.5 Loading if deemed necessary for coorfination of the step-up transformer and combiner boxes.
.6 Equipment electrical drawings.
.7 All miscellaneous equipment.
.8 Drawings to be stamped by an engineer registered with the Professional Engineers Ontario, and have education and training relevant to this discipline.
.9 Submit information regarding the proposed system, including the following:

1. A schematic plan and section of the proposed layout, to scale.
2. Number of panels.
3. Watts STC per panel.
4. Thermal output per panel.
5. Number of inverters.
6. Name plate AC rating of inverter.
7. Number of battery energy storage system modules.
8. Energy storage capacity of each energy storage module.
9. Energy storage round trip efficiency.
10. Warranted annual degradation of energy storage system.
11. Transformer weighted efficiency rating.
12. Tilt angle of array.
13. Azimuth angle of array.
14. Row spacing of array (front to front).
15. Specific yield in kWh/KWdc/year.

16. Solar array energy kWh output per year.
17. $/KWdc per project.
18. Soiling loss due to snow for December through March as a percentage.
19. System loss excluding soiling (dc, ac, shadow, etc) as a percentage.
20. Total system loss as a percentage.
21. Annual degradation estimate (solar PV array).
22. Proposed panel layout including structural elements.
23. Manufacturer and model numbers of all equipment.
24. Yield forecasting analysis including inputs and results (kWh/kWp and Performance Ratio).
25. A summary of what it opines as advantages and disadvantages to the proposed Project design and construction as described in the Owner's Statement of Requirements.
26. A list of all exceptions or clarifications it requires to the terms of the RFP, including without limitation any proposed revisions or modification to the form of Contract.

.3 Certification: Submit installer's and Product manufacturer's certification verifying compliance with the Contract Documents and conformance with CEC, CSA, IEC and UL standards.

.4 Provide a completed Toronto Hydro “Connection Impact Assessment Application” and submit to the LDC on behalf of the owner. In addition, if OTC/CCA is required by LDC; provide a completed document package and submit to the LDC on behalf of the owner.

.5 Miscellaneous closeout submittals:
- .1 Submit following to the Owner:
  - .1 keys;
  - .2 Electrical Safety Authority Certificate;
  - .3 electrical panel directories, inside panels; and
  - .4 one electrical riser diagram (laminated and framed).

.6 Commissioning Plan: Description of overall commissioning process for each system and/or subsystem.
- .1 Commissioning plan to include:
  - .1 Description of all planned activities, on individual system basis;
  - .2 Purpose/objective of each test and/or series of tests;
  - .3 Testing schedule; and
  - .4 Schedule for delivery of commissioning procedures.

.7 Commissioning Procedures: Detailed written test procedures required to perform operational and functional performance testing, through the use of simulated normal, alarm and emergency conditions, as required, in order to demonstrate each system and/or subsystem, and interfaces between systems, operate in accordance with the Contract.
- .1 Provide test procedure for each function to be tested, for each system and/or subsystem. Procedures also to include specific tests identified in Technical

Specifications. Procedure to describe individual test and steps comprising each test particularly methods and processes to follow. Each test procedure to include following items:

.1 Name of system and/or subsystem and of function to be tested;
.2 List of tests be performed and a description of purpose of each test;
.3 Setup and conditions for each test, including descriptions of test equipment;
.4 Step-by-step descriptions of each test, including but not limited to inputs and user actions for each step, detailed review of control sequence, and set points;
.5 Expected results for each test, including pass/fail criteria. Provide detailed checklists with space for check-off fields to ensure criteria passed;
.6 Line for signature and date for the contractor to witness test successfully completed;
.7 Estimated duration of each test; and
.8 List of contractor's attendees and responsibility of each party.

.8 Deficiency Reports:

.1 After completing commissioning for each system and/or subsystem, submit detailed deficiency report. Include following information:

.1 Signed attendee list.
.2 Detailed list and description of all Construction deficiencies noted during commissioning.
.3 Deficiencies under dispute.
.4 Identify Subcontractor(s) required to perform the Work.
.5 Scheduled date for correcting each deficiency.
.6 Proposed schedule for re-commissioning.

.9 Commissioning close-out report:

.1 After successful completion of commissioning for each system and/or subsystem, submit individual commissioning close-out reports. Commissioning close-out reports to include following document attachments:

.1 Final start-up and testing process reports, including operational and functional performance test results, as well as vendor start up tests.
.2 Final commissioning procedures.
.3 ESA Certificate
.4 Other reports and certificates, where applicable, as required by Authorities having jurisdiction.
.5 Pre-start health and safety review reports, where applicable.
.6 List of deferred functional performance testing, for commissioning requiring off-season conditions.
.7 Final TAB reports, where applicable.
.8 Reports of commissioning activities, including deficiencies identified and corrective actions taken.
.9 Signed list of attendees.

.10 The Owner or its representative shall be entitled to attend any performance and generation test(s) and the Contractor shall provide to The Owner confirmation in writing of the timing of such test(s) at least ten (10) Contractor in advance.

1.5 QUALITY ASSURANCE

.1 Retain a licensed Professional Engineer, registered in Province of Ontario, to perform following services for photovoltaic, solar thermal and battery system work:
- .1 Design of photovoltaic, solar thermal and battery system.
- .2 Review, stamp, and sign shop drawings.
- .3 Conduct shop and field inspections and prepare and submit inspection reports.

.2 Manufacturer's qualifications: Perform work of this Section by a company that has a minimum of five years proven experience in the manufacture of work of a similar size and nature.

.3 Installer's qualifications: Perform work of this Section by a company that has a minimum of five years proven experience in the installation of work of a similar size and nature and that is approved by manufacturer. Submit to Consultant, installer's current certificate of approval by the material manufacturer as proof of compliance.

.4 Pre-installation meeting: Arrange with manufacturer's representative, Contractor, and Consultant to inspect substrates, and to review installation procedures 48 hours in advance of installation.

1.6 DELIVERY STORAGE AND HANDLING

.1 Deliver solar photovoltaic panels to the Place of the Work properly packaged to provide protection against transportation damage.

.2 Adequately protect equipment placed in storage at the construction Place of the Work that can be affected by weather conditions, dirt or other contaminants.

.3 Follow manufacturer's recommendation on storage and exposure to extreme weather conditions.

1.7 SITE CONDITIONS

.1 Do not install the work of this Section outside of environmental ranges as recommended by manufacturer without Consultant's and Product manufacturer's written acceptance.

.2 Supply and install temporary protection and facilities to maintain Product manufacturer's, and above specification, environmental requirements before, during, and after installation.

1.8 EXTENDED WARRANTY

.1 The system, including all hardware and wiring, shall have a minimum 2-year warranty for defects in material and workmanship. In addition the panels and inverters shall have a minimum 10 year manufacturer defect warranty.

.2 Solar PV power output for the system shall not decline more than 20% over 25 years.

.3 During the system warranty period the Contractor shall respond to system related issues within 24 hours or on the next business day, upon receiving a notification from the Owner. It is understood that an issue may not be resolved within 24 hours, but the Contractor shall at a minimum provide a resolution plan and schedule within that timeframe, which shall be reviewed and approved by Owner, acting reasonably.

.4 A final inspection of all performed Work shall be conducted with the Owner between 120 to 90 days before the expiration of the warranty period. The Owner will provide a list of all defects to the Contractor within 30 days of the inspection, which defects the Contractor will have 30 days to remedy upon receipt of the list.

1.9 **MAINTENANCE MATERIALS**

.1 Supply extra maintenance materials and/or spare parts and store in a locked room as directed by the Owner.

.2 Suitably package maintenance materials in accordance with manufacturer's instructions and label to identify Product type, manufacturer, etc.

.3 Store maintenance materials, e.g., positioning, proper side up, etc., in accordance with manufacturer's recommendations.

2 Products

2.1 **MAJOR COMPONENTS**

.1 Solar photovoltaic panels manufacturers:
- .1 Panels must meet all defined specifications in Design Requirements Article.
- .2 Products listed in the California Energy Commission.

.2 Photovoltaic/Thermal dual panel system:
- .1 System shall be rated for fire per Fire Class C.
- .2 Panels to have a max. working pressure of 150 psig.
- .3 Seals must be compatible with 50% Propylene, glycol & water.
- .4 Maximum Temperature 110 deg.C
- .5 Product warranty 10 years.
- .6 Cover glass hardened.

.3 Battery energy storage system:
- .1 Battery energy storage system and accompanying hardware must be UL/CSA listed and should have a round trip efficiency of greater than 85%
- .2 Battery energy storage system manufacturer should have a presence in North America and a distribution channel in Canada
- .3 Battery energy storage system must meet all ESA requirements
- .4 Battery energy storage system must meet all the Local Distribution Company's requirements.

.4 Inverters:
- .1 Inverters must be UL/CSA listed with minimum efficiency of 97%
- .2 Inverter manufacturer should have presence in North America and a distribution channel in Canada
- .3 Inverters must meet all ESA requirements
- .4 Inverters must meet all the Local Distribution Company's requirements.
- .5 Output Voltage to match building voltage (to be confirmed by the LDC).

.5 Monitoring system:
- .1 Monitoring system shall have a client facing, publicly accessible website to view live performance
- .2 Monitoring system shall have a minimum data storage capacity of three months
- .3 Monitoring system shall have the capability to provide the Owner's staff with alarm notifications via e-mail.
- .4 Monitoring system shall enable monitoring and controlling of the energy storage system through remotely accessible battery management system, either a stand-alone application or website or connection to the BAS.
- .5 Monitoring system to be SolarVU by Cachelan complete with Weather Trak, LDC SCADA control, and Paycheck or approved equal.

.6 Balance of System (transformer, switch gear, combiner boxes, etc):
- .1 All components must be UL/CSA listed or recognized and meet all applicable code requirements.
- .2 All component manufacturers should have North American presence and a distribution channel in Canada.
- .3 Transformer weighted efficiency must be 98% or higher.
- .4 EMT conduit must be used inside the electrical room.
- .5 TECK wiring is allowed on top of roof inside a cable tray or anchored appropriately to the side of the building.
- .6 All wires shall enter combiner boxes from the bottom in order to prevent water ingress, unless otherwise approved by the Owner.
- .7 Exterior disconnects located in publicly accessible areas shall be mounted inside a lockable stainless steel enclosure, unless otherwise approved by the Owner.

.8 Weather station:
- .9 Weather station to be SolarVU-WeatherTrak by Cachelan, or approved equal.

3 Execution

3.1 **EXAMINATION**

.1 Verify condition and dimensions of previously installed Work upon which this Section depends. Report defects to Consultant. Commencement of work of this Section means acceptance of existing conditions.

3.2 **PREPARATION**

.1 Provide proper storage and equipment staging according to standard construction and installation practice of equipment manufacturer.

.2 Provide adequate supports for installation and provisions for attachments of solar panels.

3.3 **INSTALLATION**

.1 Install solar photovoltaic panels as recommended by equipment manufacturer and as required for proper operations.

.2 Install in accordance with manufacturer's written instructions, and NEC/CEC standard.

.3 Refer to Contract engineered shop drawings and installation manuals for installation procedures.

.4 Install solar photovoltaic panels according to roofing manufacturer protocol in order to maintain waterproofing and manufacturer warranty.

3.4 **START-UP AND DEMONSTRATIONS FOR OWNER'S PERSONNEL**

.1 Shall be performed by factory-trained personnel.

.2 Provide qualified technicians to demonstrate operation and/or maintenance of systems to the Owner's staff.

3.5 **COMMISSIONING, TESTING AND START-UP PROCESS**

.1 Commissioning: Process of demonstrating to The Owner, for purpose of final acceptance, that all systems and/or subsystems are installed, functionally tested, and capable of being operated and maintained to perform in conformity with the Contract, through successful demonstration of the operational and functional performance testing.

.2 Operational Performance Testing: Testing components, equipment, systems and/or subsystems to verify they have been checked and started up in accordance with the Contract, manufacturer's written instructions and other codes and standards. Range of checks and tests to verify all systems, subsystems and interfaces between them, operate in accordance with the Contract. In this context "operate" includes all modes and sequences of control operation, interlocks and conditional control responses, and specified responses to emergency conditions. Operational performance testing occurs before functional performance testing.

.3 Functional Performance Testing: Testing systems and subsystems to verify they are ready for occupancy and operation, and functioning correctly in accordance with the Contract, including correct interaction between equipment, systems and subsystems. Range of checks and tests to verify all systems, subsystems and interfaces between them, operate in accordance with the Contract. In this context "operate" includes all modes and sequences of control operation, operating set points, interlocks and conditional control responses, and specified responses to emergency conditions. Functional performance testing occurs after successful completion of operational performance testing and shall be witnessed by The Owner.

.4 Start-up and Testing Process: Verify all systems and/or subsystems forming part of the Work operate in accordance with the Contract, via successful execution of the operational and functional performance testing. Start-up and testing process is conducted by the Contractor, with support of the Subcontractor and the associated factory authorized and trained personnel and is one of the prerequisites to commissioning. The Owner may elect to witness this testing.

3.6 COMMISSIONING PROCESS

.1 Commissioning Plan:
- .1 Submit one electronic copy of draft commissioning plan to The Owner for approval.
- .2 The Owner to provide comments on commissioning plan and final 'Reviewed' or "Reviewed as Noted" commissioning plan must be available prior to submittal of Commissioning Procedures.

.2 Commissioning Procedures:
- .1 Submit draft commissioning procedures to The Owner as per reviewed commissioning plan for approval.
- .2 The Owner to provide comments on commissioning procedures and final 'Reviewed' or 'Reviewed as Noted' commissioning procedures must be available thirty (30) calendar days prior to commissioning and prior to scheduling commissioning start-up and testing process.

.3 Commissioning
- .1 Coordinate and schedule commissioning of each system and subsystem to ensure availability of The Owner. The Owner may request other personnel to witness commissioning. Unless otherwise accepted by The Owner, schedule commissioning so no more than one (1) System is commissioned at a time.
- .2 Prior to commissioning, 'Reviewed' or 'Reviewed as Noted' operating and maintenance manuals must be available to The Owner.

.3 Make adjustments and corrections to operating and maintenance manuals, in accordance with the Contract as necessary during the commissioning and submit final version, including commissioning close-out reports.

.4 Make available original equipment manufacturer's trained/certified representatives familiar with systems being commissioned to demonstrate operation in its entirety, including all control sequences. The Owner reserves right to request additional representation, at no cost to The Owner. The Owner reserves the right to request ad-hoc testing beyond the commissioning procedures, the need for which may become evident during commissioning.

.5 Provide necessary tools and equipment to perform tests as required. Test equipment configured to manufacturer's instruction and latest edition of applicable codes and standards.

.6 Where more than one (1) discipline responsible for Work regarding system being commissioned, Contractor's representative from each discipline to be present. The Owner reserves right to request additional representation, at no cost to The Owner.

.7 When The Owner personnel arrive at the Place of the Work and scheduled commissioning or re-commissioning cannot be performed as a result of deficiencies, systems incomplete, unsuccessful test results or the Contractor's representatives not present or not familiar with operation or control sequences for purposes of demonstration, commissioning will be cancelled at discretion of the Owner. Under such circumstances, the Contractor to pay all costs incurred by The Owner due to cancellation.

.8 The Owner may cancel commissioning without penalty, provided minimum of two (2) Business Days notice is given. Commissioning to be rescheduled at a date accepted by The Owner.

.9 After commissioning each system and/or subsystem, submit deficiency reports within seven (7) calendar days, where applicable. Contractor to proceed immediately to correct deficiencies in the Work, which become evident during commissioning, to satisfaction of the Owner and following an updated schedule. Reschedule and repeat commissioning, as required by the Owner, and at a date accepted by the Owner, at no additional cost to The Owner. To ensure subsequent Work has not impacted previously successful testing, repeat commissioning may be required at the Owner's discretion, which shall be supported by the original equipment manufacturer's trained/certified representatives, as deemed necessary by the Owner.

.4 Commissioning for each system and/or subsystem considered successfully completed only after:

.1 Noted deficiencies corrected and final acceptance by the Owner obtained.

.2 Operation and maintenance manuals, including commissioning close-out report.

.3 Deferred commissioning reports submitted.

.5 Deferred Commissioning

.1 If deemed necessary by The Owner, schedule and perform commissioning requiring off-season conditions immediately when suitable weather conditions permit.

.2 Correct deficiencies within fifteen (15) calendar days unless agreed otherwise with The Owner.

.3 Submit deferred commissioning close-out reports maximum twenty-one (21) calendar days after successfully completing such tests.

END OF SECTION

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END OF SECTION **7**

PART 1 - GENERAL

1.1 General

.1 Comply with the General Conditions of the Contract, Supplementary General Conditions, Requirements of Divisions 1, Basic Materials and Methods, Section 26 05 01.

1.2 Work Included

1. Work to be done under this Section shall include furnishing of labour, materials, and equipment required for installation, testing and putting into proper operation complete Electrical systems as shown, as specified and as otherwise required. Complete systems shall be left ready for continuous and efficient satisfactory operation.

.2 Catalogue Reference numbers given for individual fixture types are intended as a guide when read with the description and the fixture as finally applied. Verify catalogue references with description and co-ordinate with installation conditions, with particular regard to ceiling construction details, type and finish before ordering fixtures.

1.3 General Requirements for Luminaires

.1 Luminaires shall not be delivered to building or stored therein until dry and protected space is available for proper storage of luminaires.

.2 Submit samples of luminaires which are not catalogue items for approval. Additional luminaires shall not be manufactured until sample has been approved. Each approved sample shall be retained on job site until final completion of project. Luminaires which do not match quality and workmanship of standard sample will be rejected.

1.4 Special Requirements for Installation in Parking Level B

.1 The local Conservation Authority has deemed this level (to the ceiling line) to be below the flood proofing elevation. All fixtures are to be suitable for submersible installation (IP67 Rating). Make all connections above the ceiling line in a sealed recessed junction box. All wiring to be either installed in ceiling slab or rated for submersible installation on the ceiling surface

PART 2 - PRODUCTS

2.1 General Requirements for Luminaires

.1 Luminaires shall be suitable for individual or continuous mounting.

.2 Supply recessed luminaires, where installed in plaster or in acoustic ceilings, complete with plaster trim frame or ring and mounting brackets.

.3 Fluorescent troffers in ceiling shall be equipped with adjustable mounting brackets.

.4 Do not install or energize lamps until directed by Engineer which generally shall be just prior to occupancy of the building by the Owner.

.5 Recessed incandescent fixtures shall conform with requirements of latest bulletin of Ontario Hydro Inspection Department. Thermal insulation and combustible materials shall be kept clear of recessed fixtures.

2.2 Ballasts

.1 Fluorescent Ballasts

Fluorescent ballasts shall be high power factor, programmed start, electronic ballasts with a sound rating of 'A'. They shall carry a minimum of 2 year warranty. Power factor 0.98 minimum, total harmonic distortion of 15% maximum, Ballast factor of 0.875 minmum.

2.3 Lamps

.1 Incandescent Lamps

Incandescent lamps shall be inside frosted, 130 volt, 2500 hours extended service type.

.2 Reflector lamps shall be rated 130 volt, 2000 hours.

.3 Fluorescent Lamps

Fluorescent lamps shall be T-8, 32W, 35K, C.R.I.-85 type lamps.

.5 Compact Fluorescent lamps

Shall have single ended lamps, rated at 10,000 hours complete with integral high power factor ballast and lamp holder. Colour temperature shall be 3500 degrees Kelvin.

.5 Lamp Manufacturers

.1 Lamps shall be manufactured by:

Canadian General Electric Co. Ltd.
Sylvania Electric Canada Ltd.
Philips Electronics Ind. Ltd.

Occupancy Sensors

.1 Watt Stopper Inc. Lutron, Legrand and Hubbell equal. CSA approved devices to provide automatic control of lighting with the following components:

.1 power and slave packs;
.2 ultrasonic occupancy sensors;
.3 passive infrared sensors;
.4 wiring in conduit and mounting hardware.
5 Photocell

.2 Power packs shall be No. B347OP, self-contained, 120VAC/24VDC transformer relay system. Slave packs shall be No. S120-277-347EP.

.3 Ultrasonic sensors shall be 24VDC, solid state, omni directional (360 degrees) ceiling mounted types with user adjustable time control, adjustable sensitivity and as follows:

.1 No. W1000A – 1000 square feet coverage.

.4 Passive infrared sensors shall be 24VDC, dual element pyroelectric type with user adjustable time delay, adjustable sensitivity, fresnel lenses, LED indicator and as follows:

.1 No. CX105 complete with four (4) wire guards and four (4) B347DP power packs.

.5 Override switches shall be flush wall mounting on single gang faceplate.

.6 Wiring in conduit, mounting hardware and ancillary devices shall be provided as per manufacturer's requirements.

.7 System shall be complete with 5 year unlimited parts warranty and 1 year parts and labour warranty.

.9 Interconnect power packs with sensors to activate all sensors at the same time.

PART 3 - EXECUTION

3.1 General Requirements for Luminaires

.1 Position and aim adjustable lighting equipment as directed on the site. Position outdoor units after daylight hours as directed. Provide labour and materials necessary to accomplish this.

.2 Fixtures shall be clean at the time of final acceptance.

3.2 Luminaire Installation

.1 Locate hangers on tile centres or intersections. Mount recessed incandescents, troffers and surface mounted luminaires in or on full tiles.

.2 Verify ceiling types with the latest revised Architectural Drawings and order luminaires to suit the correct ceilings.

.3 Check lighting luminaires and mountings for their electrical and physical characteristics and relation to conditions due to building construction and mechanical equipment. Make necessary adjustments to luminaires or notification at time of shop drawings and before construction if decision on necessary changes is required.

.4 Co-operate with other trades to ensure proper installation of lighting luminaires.

.5 Carefully align luminaires, shown in continuous lines or rows, so that rows appear as straight lines.

.6 Mount luminaires perfectly level or plumb. Luminaires shall fit tightly to ceiling without showing a space or light leak between frame and ceiling.

.7 Take down any improperly installed luminaires and re-install without expense to Owner.

.8 Standard octagonal boxes may be supplied where conduits feeding luminaires in finished areas are exposed on ceiling if hanger canopies entirely cover outlet boxes and are neatly notched for conduit. Otherwise, provide cast condulet outlet boxes with a diameter larger than canopies.

.9 Do not mount luminaires above pipes, ducts or equipment. In event of unavoidable tight locations, provide hangers to clear obstructions. Check layouts of other trades on job and plan co-operatively. Luminaires in any room shall hang at one height. Obtain approval before any changes are made to layouts shown.

.10 Luminaires mounted in or on ceilings shall be supported independently of ceilings.

.11 Industrial luminaires where suspended shall be 12 mm conduit hangers and ARB ball aligners. Length and location shall clear equipment, ducts and pipes. Flexibar may be used for mounting of luminaires in mechanical areas and electrical rooms.

3.3 Lighting Luminaires

.1 Provide lighting luminaires exactly as shown and as specified. Luminaires shall be complete with necessary accessories and lamps at time of acceptance and shall be properly **CLEANED** (luminaires and lenses) at time of Substantial Performance.

3.4 Installation of Occupancy Sensors

.1 Provide occupancy sensors and associated devices to control lighting in areas as shown on drawings.

.2 Exact type of occupancy sensors and type of lenses shall be verified by the manufacturer/supplier to ensure proper coverage in sensed areas only.

.3 It shall be the Contractor's responsibility to provide, locate and aim appropriate sensors in the correct location required for complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations. Rooms shall have ninety 90 to one hundred 100 percent coverage to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room(s). The locations and quantities of sensors shown and/or noted are illustrations only and should only be used as guidelines. The Contractor shall provide additional sensors at his cost if required to properly and completely cover the respective room.

3.5 Emergency Battery Lighting

.1 Unit shall be capable of operating on a 120 volts, 60 Hz input and shall deliver power at 24 volts to battery operated 12 w halogen type lighting heads, located on unit or remote form unit as shown. Lighting load to have a minimum of 1/2 hour time basis.

.2 Battery #RG24S350, shall be a sealed pure lead type or sealed lead calcium type and shall have a minimum ten year design life expectancy, with a published warranty of five years. Where batteries are shown on the drawings provide an adjacent duplex receptacle for battery plug-in.

.3 Charger shall be designed to re-charge battery completely within 24 hours and to maintain batteries fully charged at all times without damage to battery. Unit shall have externally accessible means for testing of unit and shall have two lamps indicating AC on, and high charge.

.4 Unit shall include a low voltage cut-off protection circuit.

.5 The complete units shall be as manufactured by one of the following:

Lumacell.
Beghelli
Emergi-Lite

.6 Provide complete emergency battery lights as shown and as specified.

.7 Unless otherwise noted, mount units on the wall, as high as possible above floor. Unit shall be hardwired to source. Provide lock-on devices on breakers.

.8 Where heads are shown remote from unit, provide suitable outlet box and install head. Connect with conduit to battery and charger unit. Wire size to suit manufacturer's recommendations, but not less than #12 gauge.

3.6 Emergency Equipment Types

.1 Remote Lamphead: Lumacell Model MQM-2-LD13, 24V, 4W, MR6 LED.

.2 Cube Type: LED lamp =, Lumacell # RSQB-MLD13, 24V, 4W MR16 LED, single and double head as shown on drawings.

END OF SECTION

Part 1 GENERAL

1.1 GENERAL INSTRUCTIONS

.1 Read and conform to:

- .1 Section 01 91 13 - Facility Commissioning - General
- .2 Section 20 05 40 - Facility Commissioning - Mechanical
- .3 Comply with Division 1 requirements and documents referred to herein.

.2 Carry out testing and commissioning as specified hereunder and in:

- .1 Division 26 Electrical Systems
- .2 Division 27 Communications Systems
- .3 Division 28 Security and Safety Systems

1.2 SYSTEMS TO BE COMMISSIONED

- .1 Electrical
  - .1 Distribution including emergency power
  - .2 Standby Battery System (emergency power)
  - .3 Panelboards and branch circuit wiring
  - .4 Lighting Systems
  - .5 Lighting Control System
- .2 Communications
  - .1 Network Cabling
  - .2 Call system for Washrooms
- .3 Security and Safety
  - .1 Fire Alarm System
  - .2 Security Systems- Access Control and CCTV

1.3 DOCUMENTATION

.1 Contractor shall submit test procedures for review prior to testing and commissioning. Record test results and procedures on approved record forms and submit the forms together with copies of test certificates to consultant and Commissioning Authority for review and approval.

.2 Contractor to submit test reports for the test procedures, results of all items inspected, checked, measured and tested. Comments and deficiencies should also be noted in the reports.

.3 When results are validated, Commissioning Authority shall incorporate those records in his System Description Manual.

1.4 COMMISSIONING PROCESS

.1 Commissioning Authority: to perform and complete all work as specified in the “GENERAL” Section of this specification “Responsibilities of Commissioning Authority”.

.2 Contractors: To perform and complete all works as specified in the “GENERAL” Section of this specification “Responsibilities of Contractor”. In general, it shall include complete activation of all systems; calibration, test, and verification of performance of all components, equipment and systems; verification of performance of all systems through all specified modes of control and sequence of operation; rectification of deficiencies; recording of test results for submission; demonstration, instruction and training of Owner’s operating and maintenance personnel; follow-up during first year of operation for fine tuning and building service monitoring.

.3 Equipment verification: The Contractor shall complete the equipment verification forms for each piece of equipment. The forms shall be included in the commissioners System Description Manual. The equipment data shall include, but is not limited to:

- .1 Manufacturer’s name, address and telephone number.
- .2 Distributors’ name, address and telephone number.
- .3 make, model number and serial number, year built.
- .4 voltage, ampere rating, fault rating, frequency, breaker size, fuse size, overload size.
- .5 equipment enclosure type.
- .6 any other special characteristics.

Part 2 Testing Equipment

2.1 GENERAL

.1 Contractor and manufacturer shall provide all instrumentation and test equipment necessary to conduct the tests specified during the commissioning process.

2.2 CALIBRATION

.1 Contractor shall submit a list of equipment to be used and copies of latest equipment calibration certificates to the Commissioning Authority and Consultant for review and comments.

Part 3 Execution of Testing & Commissioning

3.1 TESTING OF ELECTRICAL SYSTEMS

.1 **Low Voltage Switchboards**: Manufacturer/ITPTA shall carry out the following:

.1 all pre-service checks, inspections and testing as recommended by the manufacturer.

.2 check and record nameplate data.

.3 check and inspect the switchboard that it is installed in accordance with the manufacturer's recommendations and to the Code requirements.

.4 check the installation is complete and is ready and safe to carry out the testing.

.5 check and report the switchboard enclosure is suitable for the environment in which it is installed.

.6 check and test grounding is completed and satisfactory prior to carrying out any test.

.7 check and record the entire switchboard is clean and free of debris before the testing.

.8 check the mechanical operation of the switches or breakers.

.9 check all connecting bolts are tightened to the correct torque values.

.10 megger test

.11 verify all protective devices are set as per the reviewed Coordination Study.

.12 test and calibrate the protective relays by secondary current injection. Record the magnitude of the test current, the actual tripping time, and the tripping time from curve.

.13 check all the indication lights and control switches for correct functions.

.14 set up, check and test the proper operations of the TVSS, measuring, indicating and recording meters.

.15 after the board is energized, check and test phase sequence, the available voltages and load on the system and each feeder. For multi-section boards with different sources, check the phase sequence, available voltage and the polarity of each source.

.2 **Low Voltage Motor Control Centres (MCC):** Manufacturer/ITPTA shall carry out the following:

.1 all pre-service checks, inspections and testing as recommended by the manufacturer.

.2 check and record nameplate data.

.3 check and inspect the MCC to ensure they are installed in accordance with the manufacturer's recommendations and to the Code requirements.

.4 check the installation is complete and is ready and safe to carry out the testing.

.5 check and report the MCC enclosure is suitable for the environment in which it is installed.

.6 check and test grounding is completed and satisfactory prior to carrying out any test.

.7 check and record the entire MCC is clean and free of debris before the testing.

.8 check the mechanical operation of the switches or breakers.

.9 check all connecting bolts are tightened to the correct torque values.

.10 megger test

.11 verify all protective devices are set as per the reviewed Coordination Study.

.12 test and calibrate the protective relays by secondary current injection. Record the magnitude of the test current, the actual tripping time, and the tripping time from curve.

.13 check and record the size of all fused switches and fuses.

.14 Check, set and record the rating and setting of the overload relays.

.15 check all the indication lights and control switches for correct functions.

.16 check all control functions for proper functioning and connections.

.17 check all interface contacts for control and indications for proper functioning and connections.

.18 set up, check and test the proper operations of the TVSS, measuring, indicating and recording meters.

.19 after the MCC is energized, check and test phase sequence and the available voltages. For multi-section boards with different sources, check the phase sequence, available voltage and the polarity of each source.

.20 check motor running current and for correct rotation.

.3 **Distribution cables:** Contractor/ITPTA shall carry out the following tests:

.1 check cables are properly installed, terminated and tightened to the correct torque values.

.2 check and record cable sizes, types and method of installation.

.3 check and confirm the installed cable sizes are of adequate rating, taking into consideration of the type of cable, the method of installation, the correction factors and any other requirements.

.4 grounding test to ensure the equipment, the conduit and the cable armour/sheath, if applicable, are properly grounded.

.5 megger test.

.6 check and measure voltage and current. For cables in parallel, measure load current on each cable.

.4 **Transformers:** Manufacturer/ITPTA shall carry out following:

.1 check and record nameplate data.

.2 check and report the transformer enclosure is suitable for the environment in which it is installed.

.3 check and record sizes and types of primary and secondary protection devices, conductor sizes and types.

.4 check cables are properly installed, terminated and tightened to the correct torque values.

.5 megger the primary and secondary windings.

.6 measure the primary and secondary winding resistances.

.7 grounding test to ensure transformer is properly grounded.

.8 polarity and phase sequence tests.

.9 sound level test for different points at 1 m (3') away from transformers.

.10 check and record transformer primary and secondary voltages and load current. Check and record transformer on-load temperatures.

.5 **Emergency Battery System:** Manufacturer shall perform tests to the specification, CSA C282, CSA Z32 and the following requirements:

.1 Prior to carrying out site test, the following items must be completed:

.1 the complete system including batteries, inverter and all controls/ monitoring shall be started in accordance with manufacturer's requirements, and report submitted.

.2 factory test report submitted and reviewed by the Consultants and the Commissioning Authority.

.3 test procedure submitted and reviewed by the Consultants and the Commissioning Authority.

.2 check cables are properly installed, terminated and tightened to the correct torque values.

.3 test all protective devices for proper shutdown and warning operations.

test all the interfaces with the transfer switches for the correct power transfer, retransfer and annunciation to BMS, fire alarm system, elevator control system and any other systems as specified.

.4 load test (using load bank/ dummy load)

manufacturer to provide a full site test report recording all the tests carried out, the results, including the results of the operation of the associated electrical and mechanical systems.

.6 **Automatic Transfer Switch:** Manufacturer/ ITPTA shall perform tests according to CSA C22.2 No. 178 and the following:

.1 check and record nameplate data.

.2 check and report the panel enclosure is suitable for the environment in which it is installed.

.3 check cables are properly installed, terminated and tightened to the correct torque values.

.4 Check, set and record all settings as per the specification requirements.

.5 check and test the switch for correct alignment and correct mechanical and electrical operation of switch in different positions.

.6 test all the electrical control, indication and interface signals with the generators, fire alarm panel, elevator control panels, building management panel or other interface panels.

.7 Test and record phase sequences and voltages.

.8 grounding test.

.9 perform all interface test with the generator for starting and stopping.

.7 **Distribution panelboards and branch panelboards:** Contractor/ ITPTA shall carry out following:

.1 check and record nameplate data.

.2 check and report the panel enclosure is suitable for the environment in which it is installed.

.3 check cables are properly installed, terminated and tightened to the correct torque values.

.4 check and test to verify the panelboard directory is correct.

.5 include the directory in the test records. The directory shall contain size of each breaker, equipment served, cable type and size.

.6 check and test the voltage drop is within the specify limit from the service entrance switchboard to the distribution panels and branch panelboards.

.7 test branch circuits voltage drop is within the requirements.

.8 grounding test to ensure panelboards are properly grounded.

.9 megger test.

.10 Measure voltage and load current on each phase. Submit test reports to Consultant. When required, re-arrange branch circuits as directed by the Consultants for proper load balancing.

.8 Coordination study and on-site testing:

.1 ITPTA shall, in accordance with the reviewed Coordination Study, set up all the protective devices, check and verify the rating and types of fuses and record all such ratings and settings in his reports.

.2 ITPTA shall test all protective devices as per the specification requirements.

.9 **Lighting systems:** Manufacturer and contractor shall carry out the following tests:

.1 prior to carrying out site test, submit a lighting system operation matrix to the Consultant and Commissioning Authority. Matrix to show the zoning layout, how each zone is controlled, and the settings, such as timer and sensor settings for each zone.

.2 check and verify all lighting fixtures are connected and switched properly.

.3 check and verify all automatic controls are connected and functioning properly.

.4 check and verify all operations shown in the matrix.

.5 check and verify the emergency lighting system, including battery lighting system, are connected and functioning properly.

.6 carry out lighting level tests as required and directed by the Commissioning Authority.

.10 **Fire Alarm System:** Manufacturer and/or ITPTA shall carry out following tests:

.1 prior to carrying out site test, submit a fire alarm system operation matrix to the Consultant and Commissioning Authority. This matrix shall include of operation of the fire alarm system and the operations of all systems interfaced with the fire alarm system.

.2 check and record nameplate data.

.3 check and report the panel enclosure is suitable for the environment in which it is installed.

.4 check and verify system is installed to specification, OBC, and S524 requirements.

.5 perform system verifications and tests according to CAN/ULC-S537.

.6 check and verify all system operations shown in the matrix.

.7 perform system integration test to verify proper fire alarm system operation, and the proper operations of all systems interfaced with the fire alarm system.

.8 Submit verification reports and system operation verification reports.

.11 **Other Communication Systems**: Manufacturer shall carry out the following:

.1 prior to carrying out site test, submit

.1 system operation matrix to the Consultant and Commissioning Authority. This matrix shall include of operation of the system and the operations of all interfaced systems;

.2 test procedures to detail what tests and how each test will be carried out. Procedure to include how the system operation will be commissioned.

.2 check and record nameplate data.

.3 check and report the panel enclosure is suitable for the environment in which it is installed.

.4 Check and verify the operation of each device.

.5 check and verify all system operations shown in the matrix.

.6 perform system integration test to verify proper system operation, and the proper operations of all interfaced systems.

.7 Submit report to include the system operation matrix, test procedures, system settings and all the test results, comments and list of deficiencies.

3.2 OPERATING AND MAINTENANCE MANUAL

.1 Contractor shall prepare and submit the Operating Manual as detailed in the specification to Consultant 6 weeks prior to the beginning of training.

.2 Contractor shall re-submit the manual should Consultant find deficiencies. Training shall not begin until the manual has been accepted by Consultant.

.3 One copy of the manual shall be forwarded to Commissioning Authority in good quality, vinyl covered binders.

.4 Project directory shall contain the names, addresses, fax numbers and telephone numbers of Contractors, Subcontractors, manufacturers and manufacturer's representatives.

.5 Each section shall be divided into following subsections:

.1 shop drawings (reduced to 216mm to 290mm).

.2 as-built drawings (reduced to 216mm to 290mm).

.3 as-built riser diagrams (reduced to 216mm x 290mm).

.4 spare parts list.

.5 equipment list.

.6 testing and verification forms.

.7 certification forms.

.8 panel directory as applicable.

.9 manufacturer's literatures on installation, operation and maintenance of the equipment, including trouble shooting procedures.

.10 recommended special tools and equipment for the operation and maintenance of the equipment.

.6 The operating procedures shall be the recommended manufacturer's operating procedures for the equipment.

.7 The maintenance procedures shall include Scope of Work, frequency of activity, parts required and necessary documentation.

.8 Spare parts list shall be manufacturers' recommended list for maintenance purposes.

.9 Trouble shooting guide shall be manufacturer's recommendations for the equipment.

.10 Equipment list shall include make, model, serial number, voltage, rated current, number of phase and wire and fault rating.

.11 Operating and Maintenance Manual shall be submitted to the Owner in 3 copies.

.12 The Systems Operating and Maintenance Manual will be used by the maintenance personnel to assist them in the daily operation of the systems.

3.3 SYSTEMS DESCRIPTION MANUAL

.1 Systems Description Manual shall be prepared by Commissioning Authority using data collected by Contractor and test results.

.2 Each section describing a system will contain as a minimum:

- .1 a basic description of the system;
- .2 system location and areas served;
- .3 a basic description of operations;
- .4 electrical services and locations;
- .5 BAS points alarm limits and setpoints;
- .6 time of Day schedules;
- .7 a schematic of the system.

.3 Commissioning Authority shall provide a copy of the Systems Description Manual to Owner.

3.4 OPERATOR TRAINING AND INSTRUCTIONS

.1 Contractor and equipment manufacturers shall provide operator training for each system and equipment.

.2 Training and instruction shall be provided by qualified technicians and shall be conducted in a classroom setting at the equipment or system.

.3 Training and instruction will begin when the Operating and Maintenance Manual has been approved and delivered to Owner.

.4 Each session shall be structured to cover:

- .1 Operating and Maintenance Manual.
- .2 operating procedures.
- .3 maintenance procedures.
- .4 trouble-shooting procedures.

.5 manufacturer's or service representative's name, address and phone number.

.5 Contractor shall prepare a detailed training and instruction plan. This plan shall include the outline of all sessions and identification of the training presenters.

.6 Submit the plan including a copy of training manual for Commissioning Authority's review and approval.

.7 Provide course documentation for up to 6 people (in addition to electronic copy).

.8 Sessions shall be coordinated and videotaped by the Contractor.

Training and instruction shall be provided for following systems. Max 4 hours training per day.

SYSTEM	MINIMUM TRAINING DURATION (hours)
Electrical Distribution- General	2
Emergency Battery System	1
Lighting & Lighting Controls	2
Fire Alarm Systems	1
Security Systems & Emergency Call Intercom	2

.9 The training and instruction requirement for the electrical system shall include a walk-through of the building by the Contractor. During the walk-through the Contractor shall:

.1 identify, describe and explain the function of the equipment.

.2 Detail explanation of the operation, including mechanical operation and electrical operation of the equipment; procedures and sequence of operation; procedures of switching, isolation and emergency switching.

.3 detail explanation of the maintenance of the equipment including the procedures and items to check for.

.4 safety procedures to be implemented before the maintenance.

.5 interlock, interface and control with other equipment.

.6 fault finding procedures.

.10 When each session has been completed, the Commissioning Authority shall sign to certify completion.

3.5 SYSTEMS DEMONSTRATION AND TURNOVER

.1 System demonstration and turnover to the Owner shall occur when:

.1 installation is complete.

.2 acceptance test conducted by the Consultant has been successfully completed.

.3 Commissioning Authority system testing has been successfully complete.

.4 training and instruction has been completed.

.5 Operating and Maintenance Manual have been accepted.

.6 System Operating Manuals have been accepted.

.7 shop drawings have been updated.

.8 as-built drawings have been completed.

.2 Systems demonstration shall be conducted by Contractor and manufacturers. The demonstration shall cover all operation and maintenance requirements and a physical demonstration of equipment installation and operation.

3.6 TESTING FORMS

.1 Contractor and manufacturers shall fill out the forms listed in this section and any other additional data sheets not included in this specification, but required for the mechanical and electrical systems of this Project.

.2 Independent Testing Agent/Manufacturer to submit test form for the Commissioning Authority's review. The test forms should contain the test procedures, and all the required testing and commissioning items.

.3 Commissioning index form shall be maintained by the Commissioning Authority to track the progress of the commissioning requirements.

.4 Electrical testing and verification forms to be completed are as follows wherever applicable, but not limited to:

.1 commissioning index form.

.2 equipment test form.

.3 system and equipment warranty dates form.

.4 system verification form.

.5 test identification form.

.6 testing and start-up schedule form.

.7 switchboard test form.

.8 motor control centre test form.

.9 Standby Battery System

.10 transformer test form.

.11 distribution cable test sheet.

.12 panelboard test form.

.13 receptacle test form.

.14 motor test form.

.15 loose starter test form.

.16 fire alarm testing and verification form.

.17 Washroom Help call.

.18 CCTV

.19 Access Control

3.7 EQUIPMENT AND SYSTEM WARRANTIES

.1 Equipment and system warranties shall not begin until the system demonstration and turnover has been conducted successfully and accepted by the Owner.

.2 Contractor shall fill-out the warranty form listing the equipment and systems and the start and finishing dates for warranty.

.3 Refer to the Division 1 and all Mechanical and Electrical divisions of the specification for the requirements during the warranty period.

.4 Contractor shall re-visit the building during the warranty period with the Consultant, Commissioning Authority and the Owner. During these visits the performance of the system shall be reviewed.

.5 At these meetings Owner, Consultants and the Commissioning Authority shall review the performance of the systems. If performance is satisfactory then no further action need to be taken. If unsatisfactory then Contractor will be instructed to correct deficiencies, at his cost, to the satisfaction of Consultants.

END OF SECTION

PART 1 - GENERAL

1.1 General Requirements

.1 Comply with the General conditions of the Contract, Supplementary General Conditions, Requirements of Division 1, Electrical Basic Materials and Methods 26 05 01.

.2 Provide a complete and operating, electrically supervised single stage, non-coded, continuous sounding, fire alarm system as shown and as further described herein. The components of the system shall be Simplex International Time Equipment Co. Ltd. whose catalogue references are given below.

.3 The System shall be fully approved by Underwriters Laboratories Inc., and the Ontario Fire Department.

.4 The complete system shall be tested and verified in accordance with ULC 524 and as per latest, 'Standard for the Verification of Fire Alarm System Installations'. Upon completion, a Certificate of Verification and a copy of the Verification Report shall be submitted to the Engineer.

.5 The complete system shall be tested in the presence of the Engineer, Owner's Representative on completion of the verification. Tests shall demonstrate that the fire alarm system will function in an acceptable manner. The Engineer shall be the final authority in determining the acceptable manner of operation.

.6 Include all costs for setting up and testing the fire alarm system as directed by the Engineer.

.7 The System shall carry a one year warranty from date of acceptance by the Owner.

.8 The successful fire alarm system supplier shall provide on-site instruction classes to familiarize personnel with the operational techniques and procedures for the system.

.9 ULC and CSA standards and Ontario Hydro Code shall establish installation requirements.

.10 Conductors entering the control panel shall be identified and terminated on individual terminals.

.11 The main annunciator shall be a back lit active type, flush mounted with zone schedule complete with suitable back box and anodized brushed aluminium frame. This unit shall be fully multi-plexed, operating on 2#18AWG TW/SH and 2#14AWG conductors only.

.12 Provide wiring for sprinkler system supervisory switches (trouble) for the single sprinkler head located in the Garbage Room – L14 and connect to fire alarm systems.

1.2 Work Included

1 Work to be done under this Section shall include furnishing of labour, materials, and equipment required for installation, testing and putting into proper operation complete

Electrical systems as shown, as specified and as otherwise required. Complete systems shall be left ready for continuous and efficient satisfactory operation.

1.3 Shop Drawings and Documents

.1 Prepare maintenance schedule. Contractor to correct shop drawings to provide 'as-installed' record.

.2 Shop drawings for the Fire Alarm System shall include copies of documents to substantiate ULC listing for all items, identified by catalogue.

.3 Prepare a riser diagram of the complete system showing all devices and necessary interconnecting wiring.

PART 2 - PRODUCTS

2.1 Main Control Panel

.1 Supply and install Fire Alarm System equipment, complete with conduit, wiring, etc., as shown on the drawings and as specified below.

.2 The fire alarm control panel shall be a Simplex 4100-800l Series flush mounting, sized to house the required circuits and space for expansion as described and as shown. Monitoring windows shall form part of front door and shall provide clear and complete presentation of all zone and function information without the need of opening the door. The door shall be supplied complete with a lock and two keys.

2.2 Fire Alarm Signals

.1 Horn/Strobe Combination

.1 Fire alarm horn/strobe combination units shall operate on the same pair of conductors (2 wires). Sound output for the horn at 10 feet shall be field selectable for 90 or 95 dBA anechoic. (During installation set for 90 dBA or low audible output). The horn/strobe shall provide a synchronized temporal (Code 3) horn tone and synchronized strobe. The notification appliances shall be designed so that the audible signal may be silenced while maintaining strobe activation. i.e. Upon activation of the audible silence function of the Fire Alarm Control Panel, the audible signal shall be silenced while maintaining strobe activation. Horn/Strobes in Music Rooms shall be set to "low" audio output setting.

.2 Edwards model No. 757-5A-T

.3 Fire alarm horn/strobes shall mount to a 4" square deep (2 1/8") back box. Where horn/strobes are to be surface mounted, provide a red finished surface back box with no knockouts.

.4 Edwards model No. 757-5B

2.3 Manual Alarm Stations

1 Manual stations shall be #270-SPO for semi-flush mounting. Single action stations shall be the non-coded, flush (or surface) mounted type. Manual stations shall be breakglass, key locked and have one set of sealed N/O contacts. It shall have a recessed pull lever to prevent accidental operation. For surface mounted applications surface cast back boxes shall be provided.

2.4 Automatic Detectors

1 Automatic Detector stations generally shall be No. 2800 Series, 88 deg. C (190 deg. F) the detectors shall be ceiling mounted on flush octagonal outlet boxes complete with adapter plates to conceal outlet box.

2.5 Photo Electric Smoke Detectors

.1 Photo electric detectors shall be Model #6270C, complete with base #6251C-001A, flush activated by the presence of invisible combustion gases.

2.6 Duct Smoke Detectors

.1 Duct smoke detectors #6266C Photo Electric Type complete with duct housing #6260C and #62 sampling tube 72" long connected to fire alarm system.

.2 Provide, install and wire all duct smoke detectors.

2.7 Fire Alarm Peripheral Devices

.1 Manual Pullstations: constructed of high impact, red lexan, breakglass stations shall have a hinged front, model #270-SPO.

.2 Provide a tamperproof, clear Lexan shield and red frame that easily fits over manual pullstations for all ground floor pullstations, Simplex model #STI-1100. When it is lifted to gain access to the station, it sounds a loud, piercing warning horn. Immediate attention is called to the pullstation and a prankster will run a risk being caught, before actuating the alarm. Legitimate alarms can still be initiated. The battery powered STI-1100 can be silenced by simply lowering and realigning the shield.

2.9 System

.1 The normal power supply to the fire alarm system shall be 120/208V AC 60 hZ.

.2 Provide class B alarm transmitting station circuits as required by the operation of manual and automatic stations and as shown on the drawings, each with integral trouble and alarm lamps.

.3 Provide Fire Department module to permit transmission of alarm through Bell Canada connection. Bell Canada lease line and system interface equipment will be by the Owner.

.4 Provide individual auxiliary relays with two NO/NC contacts for actuation of fan shut down operations as required for the Mechanical Systems and for actuation of door release devices.

.5 Provide the necessary system trouble circuitry with a ring-back feature and provision for remote trouble signal devices.

.6 Supervise all station, supervisory and signal circuits electrically so that a single open circuit inside or outside the control panel, or removal of a detection device or a bell, operates the trouble signal and does not prevent the normal operation of any other circuits.

.7 Supervise all wiring so that a ground operates the trouble signals. Indicate with a pilot lamp the condition. A single ground on any conductor shall not prevent the normal operation of the system and shall not cause an over current device to trip or blow.

.8 Supply the system from two sources of power and if the preferred source fails, transfer automatically to the alternate source and operate the trouble signals. When preferred power is restored, transfer the system automatically back. Indicate with a pilot lamp the power failure condition. Failure of the preferred over current device shall not cause the trouble signals to become inoperative.

.9 Supervise all over current devices, modules, and relays so that a fault of an over current device or removal of a module or a relay operates the trouble signal.

.10 All external circuits including box, signals annunciator trouble, auxiliary circuits, power supply units, etc. shall be over current protected so that a fault in any one of the above circuits shall not interfere with any other circuit in the group.

.11 Provide system reset switch in the main control panel to permit alarm silencing (incase of shorting).

.12 Provide a 'power-on' LED indicator which shall be on at all times when the primary source of power is connected.

2.10 D.C. Standby Power

.1 Power: supplied from gell-cell sealed maintenance free batteries. Charger designed to suit the characteristics of the batteries providing automatic boost charge facility when the battery bank potential falls below acceptable voltage for maintaining a working system and returns to float charge when the battery bank reaches maximum acceptable voltage.

.2 Charger: automatic constant voltage battery charger shall be rated to recharge to at least 80% within 12 hours. Float and equalized adjustment potentiometers. AC and DC over current protection. Current limiting.

.3 Batteries: automatic charger and D.C. volt ammeters each with a 2% tolerance may be part of the control panel providing that the capacity of the batteries are sufficient to

maintain the system for 24 hours and still have signal ringing power afterwards, for at least 5 minutes.

.4 Trouble Signal Unit: provide a flush mounted remote trouble signal unit to provide audible and visual indication of trouble.

2.11 Operation

.1 The operation of any detector, pull station, or similar device shall cause all of the audible devices in the building to operate until the device and panel are restored to normal. Trouble signals shall be automatically disconnected during an alarm.

.2 System shall be capable of normal operation at 85 to 110% of rated supply voltage. Voltage above and below these limits shall initiate transfer to standby supply, and actuate trouble indication.

.3 Alarm initiating devices shall be grouped in zones. Appropriate zone of alarm indication shall be displayed by electrically supervised lamp annunciator on the control unit and on remote annunciators.

.4 Operation of Air Duct Detectors in Individual Supply (S.A.) Air Systems shall initiate alarm to main system and shut down air handling system. Any alarm condition reported to the fire alarm control panel shall shut down all air handling units.

.5 Failure of any fuse (except auxiliary fuses) loss of main power, loss of standby power, a broken detection or signal circuit conductor, or single ground fault shall result in a distinct trouble signal at the control panel and at any other location indicated on the drawings. The audible trouble signals may only be silenced manually at the control panel by transferring to a distinct trouble silenced visual indication and the silencing mechanism must be automatically reset upon correction of the fault.

.6 Silencing of Alarm Signals shall be automatic after 5 minutes of Alarm operation if permitted by regulation. Restoration of the operated device to normal and manual resetting of the control panel shall override this timer.

.7 A subsequent alarm turned in from another box circuit shall cause the alarm sequence to be re-initiated operating as above.

.8 Trouble operation shall consist of trouble signal light and switch part of the control panel and operate when any of the following trouble conditions develop:

.1 open box circuit,
.2 open alarm signal circuit,
.3 ground fault,
.4 power failure,
.5 operation of any over current device,
.6 operation of any supervisory switch devices,
.7 annunciator lamp burnout.

.9 Audible trouble signals shall be silenced under alarm conditions to avoid confusion.

.10 Supervise all mechanisms such that none can be left 'OFF' or deactivated without causing the trouble signals to operate.

PART 3 - EXECUTION

3.1 Installation

.1 ULC, CSA Standards and Ontario Electrical Code shall establish installation requirements.

.2 Conductors entering the control panel shall be identified and terminated on individual terminals.

.3 Wiring for audible signal circuits shall be No. 12 AWG minimum. Voltage drop to any signal shall not exceed 10 percent. Wiring for detection circuits shall be No. 14 AWG minimum. Wire resistance shall not exceed 50 Ohms. Conductors shall be connected in accordance with manufacturer's wiring diagram and run in conduit throughout.

.4 Wiring must be cut at each automatic and manual station and device and connected to the four terminals provided on the unit. (These connections ensure supervision of the circuit. Looping of the wires under terminal screw is not permissible). All wiring shall be continuous between control panel, detectors stations and signals. Splices where permitted by the Engineer shall comprise soldered joints.

.5 Install resistor for signal circuit in a suitable box adjacent to the last signal of the signal circuit. If diodes are used, install in the outlet box, of the last signal of the signal circuit and indicate on signal. End-of-line resistors for station circuits shall be mounted in flush box, maximum of 1829mm (6 feet) above floor beyond last device on circuit.

.6 Mount detectors on ceiling as per ULC-S524 standard unless otherwise specified herein, at the highest point where variations in ceiling height exist. Do not mount detectors on sides, undersides or less than 300mm (12") from beams, joists, open web steel joists or any structure projecting below actual ceiling height.

.7 Should interference from obstruction, lamp positions or heat radiating surfaces be encountered in locating any detector where shown, locate the detector as near as possible to the indicated position, clear of obstacles to the satisfaction of the Architect.

.8 Identify signal circuit, box circuit, auxiliary circuit wiring at fire alarm control panel, annunciator, terminal boxes or elsewhere on completion of work.

3.2 Test

.1 Retain the services of the equipment supplier to provide Special Commissioning 'Verification, Inspection and Certification' and to supervise the connection, initial test and adjustment of the system.

.2 Verification procedure shall include providing proper functioning and connection of each device and function of the systems. Furnish upon completion of the work, a letter from the manufacturer as evidence that such tests and instruction have been performed to their satisfaction and additionally to indicate that:

.1 system complies with manufacturer's installation;

.2 installation is acceptable for Warranty;

.3 completed system complies with regulations concerning supervision of functions, signals stations and automatic detectors;

.4 test completed systems for Building Approval Authority. Advise Authority when 'Verification' is to be performed.

3.3 Smoke Verification and Operation

.1 Provide all necessary software and/or equipment to provide the following alarm verification procedure for all system smoke detectors:

.1 The activation of any system smoke detector shall initially delay any alarm programming for 30 seconds. Should a second smoke detector from a different zone or any manual station, heat detector or waterflow switch go into alarm during the 30 second period, the system will respond to the alarm condition immediately. If no other alarms are reported during the 30 second period, the system will automatically reset the activated detector and wait for a second alarm activation.

.2 If within one minute after reset, a second alarm is reported from the same or any other smoke detector, the system shall react to the alarm immediately, otherwise the system will assume the initial alarm was false and resume normal operation. The system will record the errant alarm in its verification log.

.3 The Alarm Verification operation shall operate on smoke detector alarms only. Any other activated initiating devices, such as manual stations, heat detectors or flow switches, on the same zone or any other zone, shall abort the Alarm Verification operation and process the alarm immediately.

3.4 System Walktest

.1 Provide all the necessary software and/or equipment to provide the following one-man system testing procedure:

.1 Initiating the walk-test mode shall automatically disconnect the central station and auxiliary control circuit relays, and create a system trouble indication on the control panel.

.2 The alarm activation of any initiating device shall cause the audible signals to pulse one round of code over the alarm signal circuits identifying the zone of the alarm to the testing technician without having to return to the fire alarm control panel.

.3 After the testing of the device and the sounding of the zone code, the system shall automatically reset itself, and await the next device to be tested.

.4 Any momentary opening of an initiating or indicating appliance circuit shall cause the audible signals to sound for four (4) seconds to indicate the trouble condition.

.5 Actuation of the Walktest program shall not require any special tools or programming knowledge by the owner of operator.

3.5 Inspection Certification

.1 Retain services of the manufacturer to perform test and provide the following documents:

.2 A copy of the inspecting Technician's report showing location of each device, and certifying the test results of each device.

.3 A Certificate of Verification confirming that the inspection has been completed and showing the conditions upon which such inspection and certification have been rendered.

.4 Proof of liability insurance for the inspection.

END OF SECTION

1 General

1.1 **SECTION INCLUDES**

.1 Labour, Products, equipment and services necessary for earthwork Work in accordance with the Contract Documents.

1.2 **REFERENCES**

.1 ASTM D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.

.2 ASTM D4253, Test Method for Maximum Index Density and Unit Weight of Soil Using a Vibratory Table.

.3 Enbridge, Third Party Requirements in the Vicinity of Natural Gas Facilities.

.4 OPSS, Ontario Provincial Standard Specification.

.5 Technical Standards and Safety Authority, Guideline for Excavation in the Vicinity of Utility Lines.

1.3 **SUBMITTALS**

.1 Reports:
- .1 Submit written laboratory test reports.
- .2 Submit written field inspection and test report results after each inspection.

.2 Submit dewatering methods 30 days in advance for review by Consultant. If well point system is required, Engineer shall design system and supervise installation.

.3 Submit to Consultant details of locations where surplus soils and other materials are to be disposed of or reused. Include each disposal/reuse Site and type of surplus soil or other material, location of the disposal/reuse Site, operator's name and business address, type of license under which Site operates, and criteria used by Site to access suitability of surplus material for disposal.

.4 Submit to Consultant, within 48 hours of a load of surplus soil or other material leaving the Site, a daily register recording the time and place of disposal/reuse of each load signed by a representative of the disposal site. Such documentation must be submitted before payment for excavation will be made.

1.4 **QUALITY ASSURANCE**

.1 Have shop drawings signed and sealed by a Professional Engineer licensed in Province of Ontario and having experience in design and inspection of shoring, bracing, underpinning and dewatering required to complete Work.

.2 Conform to the Technical Standards and Safety Authority's 'Guideline for Excavation in the Vicinity of Utility Lines' and Enbridge's 'Third Party Requirements in the Vicinity of Natural Gas Facilities' as required for work of this Project.

1.5 **SITE CONDITIONS**

.1 Geotechnical conditions: For information on subsurface conditions refer to Section 02 32 00 and Volume 3.

.2 Cultural heritage resources: If Cultural Heritage Resources (such as archaeological sites, artifacts, building and structural remains, and/or human burials) are encountered during performance of Work, contact Consultant immediately and suspend Work in immediate area until assessment has been completed by Ministry of Culture, Tourism and Recreation. Perform required measures to mitigate negative impacts on found resources to acceptance of Consultant.

1.6 **PROTECTION**

.1 Existing buried utilities and structures:
- .1 Size, depth and location of known existing utilities and structures are indicated for guidance only. Completeness and accuracy is not guaranteed.
- .2 Prior to commencing any excavation Work, have authorities stake out utility locations to prevent disturbance during Work.
- .3 Confirm locations of buried utilities by careful test excavations. Hand dig test excavations as necessary.
- .4 Maintain and protect from damage, water, sewer, gas, electric, telephone and other utilities and structures encountered. Obtain permission of Consultant before moving or otherwise disturbing utilities or structures.

.2 Existing neighbouring buildings and surface features:
- .1 Conduct with Consultant, a condition survey of existing neighbouring buildings, trees and other plants, lawns, fencing, service poles, wires, and paving, survey bench marks and monuments which may be affected by Work.
- .2 Protect existing neighbouring buildings and surface features which may be affected by Work from damage while Work is in progress and repair damage resulting from Work.
- .3 Where excavation necessitates root or branch cutting, perform Work in accordance with Authorities having Jurisdiction.
- .4 Confirm with Consultant, condition Survey of buildings and structures undertaken by Consultant.

.3 Temporarily cover local existing catch basins and maintenance holes to prevent entry of earth or debris. Ensure adequate surface drainage in affected area is maintained.

.4 Protect Work or work of other Contracts in progress or completed and protect existing properties, stored Products, services, utilities, trees, landscaping and natural features from damage.

.5 Protect excavations against flooding and damage and install and maintain appropriate warning devices during construction and during time when Work is closed down for any cause.

.6 Protect bottom of excavations that will support foundations, slabs, pavements etc. from frost or freezing.

.7 Keep access roads clear of debris and dirt resulting from Work of this Section to acceptance of Authorities having jurisdiction.

.8 Shoring, bracing and underpinning: Comply with local regulations, authorities having jurisdictions and requirements specified.

2 Products

2.1 **MATERIALS**

.1 Select fill: Subject to approval of Consultant consisting of reusable fill excavated from Site or imported fill that is free of organic matter, rubble and material other than soil. Maximum particle size of half thickness of lift specified, moisture content at time of placing 2% maximum over its optimum moisture content and is either non plastic or has a plasticity index of 25% maximum.

.2 Granular A fill: Imported Granular A fill, free of organic matter and, in accordance with OPSS 1010.

.3 Granular B Fill: Imported Granular B fill free of organic matter and in accordance with OPSS 1010.

.4 Clear Stone fill: 19 mm clear stone in accordance with OPSS 1004, free of organic material and fines.

.5 Unshrinkable fill: 0.7 MPa cement stabilized backfill conforming to requirements of CAN/CSA A23.1/A23.2-M.

3 Execution

3.1 **EXAMINATION**

.1 Verify condition and dimensions of previously installed Work upon which this Section depends. Report defects to Consultant. Commencement of Work means acceptance of existing conditions.

3.2 **LINES AND ELEVATIONS**

.1 Establish lines and elevations from Control Points shown on Contract Drawings.

.2 Have lines and elevations established by Registered Ontario Land Surveyor or qualified Civil Engineer registered in Province of Ontario.

.3 Protect and maintain Control Points and Bench Marks as long as they are required.

3.3 **STRIPPING**

.1 Do not handle topsoil while in wet or frozen condition or in manner in which soil composition is adversely affected.

.2 Strip topsoil from working area in locations shown.

.3 Strip topsoil to depths indicated. Avoid mixing topsoil with subsoil.

.4 Stockpile topsoil in locations directed by Consultant. Stockpile to height not exceeding 2 m. Remove excess topsoil from Site.

3.4 **REMOVAL OF WATER**

.1 Dewatering during the construction period:
- .1 Contain all private water on the site and have said private water hauled off-site by way of a hauler approved by the Ontario Ministry of the Environment and Climate Change during the construction dewatering phase.
- .2 All private water shall be hauled off-site to an approved facility during the course of excavation and shoring, until the end of the construction dewatering phase.
- .3 Before excavation commences, provide the name of the hauler under contract, a copy of the hauling contract and purchase order, and specific controls that shall be implemented to prevent any discharge into the sanitary, combined sewers, and/or storm sewers from the property.
- .4 Put all necessary controls and training of the on-site personnel in place to prevent any discharge from entering the sanitary sewer, combined sewers, and/or storm sewers during construction, shoring and excavation.
- .5 Hauling manifests shall be provided to Toronto Water, Environmental Monitoring and Protection Unit on a monthly basis (email to pwreporting@toronto.ca).
- .6 If at any stage of the development, changes are made to the proposal or if the Property Owner wishes to discharge any amount of private water to the City sewer system, a discharge approval shall be required in the form of a permit or agreement from the Toronto Water, Environmental Monitoring and Protection Unit.
- .7 A detailed hydrogeological report is required in order to request discharge permit or agreement pursuant to Chapter 681, Sewers, of the City of Toronto Municipal Code ("Chapter 681"), from Toronto Water, Environmental Monitoring and Protection Unit.

.2 Keep excavations and trenches free of water throughout construction period.

.3 Groundwater removal:
- .1 Lower groundwater level and maintain at depth below lowest point of excavation to ensure a dry stable surface.
- .2 Dewater to prevent loss of soil and maintain stability of sides and bottom of excavation and of adjacent structures.
- .3 Dispose of water in conformance with applicable by-laws and in a manner not detrimental to public and private property, or portion of Work completed or under construction.
- .4 Supply and install settling basins, or other treatment facilities to remove suspended solids or other materials before discharging to sewers, water courses or drainage areas in accordance with authorities having jurisdiction.
- .5 Perform testing on settlement tank discharge to confirm that effluent meets sewer bylaw requirements. Locate tanks to acceptable area determined by Consultant.
- .6 Should method of dewatering fail to achieve conditions specified above, Consultant reserves right to revise methods and procedures at no cost to Owner.

.4 Surface water removal:
- .1 Remove surface run-off in a manner that will prevent loss of soil and maintain stability of sides and bottom of excavation. Obtain Consultant's approval of dewatering method to be used.
- .2 Discharge surface water into existing storm drainage system only if accepted by local authorities.

.5 Do not obstruct flow of surface drainage or natural water courses.

3.5 EXCAVATION

.1 Remove concrete, masonry, paving, demolished foundations and rubble and other obstructions encountered during excavation Work.

.2 Do not disturb soil within drip line of trees or shrubs that are to remain. If excavating through roots, excavate by hand and cut roots with sharp axe or saw in a manner acceptable to authorities having jurisdiction.

.3 Excavate to required lines and grades shown on Contract Drawings with allowance for subsequent Work including shoring, bracing and formwork. Make excavation clean and clear of loose material and true to size.

.4 Protect stockpiles of fill against contamination and moisture absorption.

.5 Do not undermine adjacent structures. Where it is necessary to have footings at different levels, found upper footing below imaginary 10-horizontal-to-7 vertical line, or as otherwise indicated, drawn up from base of lower footing. Protect adjacent foundations from frost.

.6 Have excavations in excess of 1200 mm in depth conform to requirements of Occupational Health and Safety Act, and Regulations for Construction Projects.

.7 Do not expose shale at subgrade elevation to drying cycles and in any case, following inspection, cover with minimum 50 mm of lean concrete within 4 hours after exposure.

.8 Fill excavations for foundations which are, through error, carried below elevation shown or approved depth, with 15 MPa concrete, or as directed by Consultant.

.9 Trim, and remove loose material, debris and organic material from excavations. Where material at bottom of excavation is disturbed, remove disturbed material and re-compact to density equal to or better than undisturbed soil or backfill with lean concrete as directed by Consultant.

.10 When excavations are complete, prior to commencement of subsequent Work, request Consultant for inspection of excavation Work.

3.6 TRENCHING

.1 Excavate trenches to lines and grades indicated and to a depth of 75 mm minimum below invert elevation and slope established for pipe, and backfill to invert elevation of pipe with specified granular material.

.2 Unless otherwise authorized by Consultant, do not excavate more than 30 m of trench in advance of installation operations and do not leave open more than 15 m at end of day's operation. Remove unsuitable material from trench bottom to extent and depth as directed by Consultant.

.3 Backfill Over-excavation with granular material and compact.

.4 If unstable soil conditions are encountered, excavate trenches to depth directed by Consultant and backfill to correct elevation with backfill material.

.5 Remove loose material from bottom of trenches to ensure granular material is placed against undisturbed soil.

.6 Compact bedding and grade as required for even and uniform support on each length of pipe.

.7 Where excavating is required adjacent to and parallel with and below any footing, submit excavation and backfill procedures to Consultant for review prior to start of excavating.

.8 Keep width of trenches to a minimum to ensure minimum span for pipe to be supported.

.9 Make excavations for siamese connections of sufficient size and depth to accommodate crushed stone as required. Hand place stone and tamp around and below connection as required to ensure proper drainage of siamese connection.

3.7 EXCAVATED MATERIAL DISPOSAL

.1 Except for material to be used as select fill, immediately remove and dispose of excavated material from Site.

.2 Remove and dispose of construction rubble, abandoned gas, water and sewer pipes, valves, valve boxes and fittings, maintenance holes, frames and covers and other material which may be encountered during excavation but not indicated on Contract Drawings.

3.8 **BACKFILLING**

.1 Do not proceed with backfilling operations until walls, slabs, dampproofing and below grade Work has been inspected and accepted by Consultant.

.2 Backfill areas which are free from debris, snow, ice, water and frozen ground.

.3 Do not use backfill material which is frozen or contains ice, excess water, snow or debris.

.4 Do not backfill on or against any membrane or protection board covered dampproofing with jagged rock or other sharp objects which might damage dampproofing.

.5 Limit vertical drop of backfill material to 2000 mm.

.6 Use only rubber-tired vehicles over roof of structure during backfilling, maximum tire pressure 70 kPa. Metal-tracked vehicles will not be allowed on roofs for compaction purposes.

.7 To avoid pockets and voids, remove sheathing and shoring materials that require removal, as backfilling progresses.

.8 Prior to backfilling or placing concrete on exposed soil subgrade, proof roll subgrade to identify soft or loose areas. Proceed with placing backfill or concrete only after inconsistencies identified by above procedure have been reworked and compacted or excavated, backfilled and compacted as required to eliminate such conditions to acceptance of Consultant.

.9 Place backfill material, grade and compact to levels shown on Contract Drawings.

.10 Place backfill materials in uniform layers 200 mm maximum loose thickness unless specified otherwise.

.11 Ensure each layer is compacted, and accepted by Consultant, before placing succeeding layers.

.12 Unless otherwise indicated, use specified granular material from bottom of trench to 300 mm above top of pipe or 150 mm above top of electrical conduits. Hand place in 150 mm layers and compact carefully to ensure proper backfilling and compaction around bottom quadrants and sides of pipe.

.13 For backfill from 300 mm above top of pipe or 150 mm above electrical conduits to sub-grade level, use select fill unless otherwise noted. Compact either by hand or by machine.

.14 Do not backfill trenches until piping, conduits and cables therein have been inspected, tested, and approved by inspection authorities having jurisdiction and Consultant.

.15 Prior to backfilling of trenches, remove wood block or wedges used to prevent movement of piping during tests.

.16 Where there is a common boundary between select fill and granular fill or unshrinkable fill, place select fill after granular fill has been compacted. Place and compact fill around free standing structures evenly on all sides of structure simultaneously in layers sloping away from structure.

.17 During backfilling, take care to avoid displacing or damaging Utilities Work and Services.

.18 Notify Consultant prior to commencement of backfilling and compacting operations.

3.9 **COMPACTION**

.1 Compaction densities for select fill and granular fill materials will be determined by ASTM D698. Compaction densities for clear stone will be determined by ASTM D4253.

.2 Add water if necessary to obtain required densities. Correct irregularities or depressions that may develop during compaction by removing or adding material to form a smooth and uniform surface.

.3 Shape and roll alternately to obtain smooth, even and uniformly compacted base.

.4 If material is excessively moist, aerate by scarifying with suitable equipment until moisture content is corrected.

.5 In areas not accessible to rolling equipment, compact to specified density with mechanical tampers acceptable to Consultant.

.6 Compact backfill materials in accordance with Geotechnical Report providing the following as a minimum:
- .1 Imported fill: 98% standard Proctor maximum dry density (SPMDD).
- .2 Under slabs, walks and pavements: 100% (SPMDD).
- .3 All other areas: 95% (SPMDD).

3.10 **GRADING**

.1 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.

.2 Place material only on clean unfrozen surface, properly shaped and compacted and free from snow and ice. Ensure no frozen material is used in placing.

.3 Grade as necessary to bring Work areas to required elevations. Supply additional material required to obtain new grade levels. Place and compact as specified.

.4 Grade drainage ditches to elevations indicated on Contract Drawings.

.5 Maintain positive drainage.

.6 Grade materials using methods which do not lead to segregation or degradation of aggregate.

.7 Shape each layer to smooth contour and compact to specified density before succeeding layer is placed.

.8 Remove and replace that portion of layer in which material becomes segregated during spreading.

.9 Slope grade away from buildings 1:50 minimum.

.10 Make graded areas smooth to profile, free of debris, with local excavations and depressions filled and compacted.

.11 Do not disturb soil within branch spread of trees and shrubs remaining.

.12 Cultivate entire area which is to receive topsoil to a depth of 100 mm. Repeat cultivation in those areas where equipment used for hauling and spreading has compacted soil.

.13 Remove surface debris, roots, vegetation, branches and stones in excess of 50 mm in diameter.

3.11 FINISH GRADING

.1 Fine grade and loosen topsoil. Eliminate rough spots and low areas to ensure positive drainage. Prepare loose friable bed by means of cultivation and subsequent raking.

.2 Roll to consolidate topsoil for areas to be seeded or sodded leaving surface smooth, uniform, firm against deep foot printing, and with fine loose texture to approval of Consultant.

3.12 UNSHRINKABLE FILL

.1 Place unshrinkable fill in locations indicated on Contract Drawings or where Work area is too limited to permit proper placing and compaction. Obtain Consultants approval prior to placing unshrinkable fill. Place in accordance with supplier's written instructions.

.2 If embedded items occur in area being backfilled, coordinate with appropriate trades to ensure that disturbance of embedded items during backfilling is prevented.

3.13 **RESTORATION**

.1 Upon completion of Work, remove surplus materials and debris, trim slopes, and correct defects as directed by Consultant.

.2 Clean and reinstate areas affected to acceptance of Consultant.

END OF SECTION

1 General

1.1 REFERENCES

.1 Ontario Provincial Standard For Roads and Municipal Services, Volume 1 – Section 314 – Construction Specification For Untreated Granular, Subbase, Base, Surface Shoulder, and Stockpiling.

.2 Ontario Provincial Standard For Roads and Municipal Services, Volume 1 – Section 501 – Construction Specification For Compacting

.3 Ontario Provincial Standard For Roads and Municipal Services, Volume 2 – Section 1001 – Material Specification For Aggregate – General

.4 Ontario Provincial Standard For Roads and Municipal Services, Volume 2 – Section 1010 – Material Specification For Aggregate – Base, Subbase, Select Subgrade, and Backfill Material

.5 Ministry of Transportation – Laboratory Testing Manual – Section LS-602 Sieve Analysis of Aggregate

1.2 QUALITY ASSURANCE

1. The Contractor is to ensure that the sub-grade and preparatory work in advance of the sub base course surface has been reviewed by Consultant before placing finish surfacing.

2. Inspection and compaction tests of sub-grade, sub-base materials or the supporting base components will be carried out by an independent testing laboratory. Costs of tests will be paid for by the Contractor. Compaction tests of the sub-grade and sub-base materials or the supporting base components must be submitted to Consultant for approval prior to the installation of the Rubber safety surface.

2 Material

2.1 GRANULAR A

.1 Granular A may be produced by crushing one or more of the following:

1. Quarried bedrock
2. Naturally Formed deposits of sand, gravel, and cobbles
3. RAP (Reclaimed Asphalt Pavement) up to 30% by mass
4. RCM (Reclaimed Concrete Material)
5. Air-cooled blast-furnace slag or nickel slag
6. Glass or ceramic materials up to 15% by mass combined

.2 Granular may contained up to 100% RCM.

.3 Granular A shall conform to the following grain size distribution specification as follows:

SIEVE DESIGNATION	Percentage Passing by Mass
	GRANULAR A
150 mm	N/A
37.5 mm	N/A
26.5 mm	100
19 mm	85-100 87-100*
13.2 mm	65-90 75-95*
9.5 mm	50-73 60-83*
4.75 mm	35-55 40-60*
1.18 mm	15-40
300 µm	5-22
150 µm	N/A
75 µm	2-8 2-10**

2.2 **GRANULAR B**

.1 Granular B material shall conform to the requirements of OPSS Division 10.

.2 The combined amount of deleterious material shall not exceed 1% by mass.

.3 Granular B Type II shall only be obtained from crushing quarried bedrock, air-cooled blast furnace slag or nickel slag. Steel slag and reclaimed material shall not be used in the production of Granular B Type II.

.4 Gradation Requirements

.5 Where Granular B is used for granular backfill for pipe subdrains, 100% of the material shall pass the 37.5 mm sieve.

.6 Granular B Type II shall conform to the following grain size distribution specification as follows:

Tyler Sieve Size	Granular B Type II Percent Passing
150 mm	

106 mm	100
37.5 mm	
26.5 mm	50 - 100
19 mm	
13.2 mm	
9.5 mm	
4.75 mm	20 – 55
1.18 mm	10 – 40
300 µm	5 – 22
150 µm	
75 µm	0 - 10

3 Construction

3.1 GENERAL

.1 Material shall be kept free from clay and other types of deleterious material for the duration of the Contract. The Contractor's operations shall not disturb underlying work.

.2 Material shall be placed without segregation in uniform layers such that the thickness of the compacted layer is not great than 150mm.

.3 Subbase shall be bladed to a smooth surface in conformance to the required cross-section and maintained until placement of a subsequence layer, where applicable.

.4 Prior to closing down operations for the completion of each day's work, the subbase material shall be bladed and compacted and, if necessary, covered with sufficient base material to carry traffic.

.5 The granular base shall be maintained to the tolerance in grade and cross-section and to the specified compaction until the project is accepted or, if the Contract includes paving, until the surface is paved.

.6 All soft spots in the subgrade and any material deemed to be frost susceptible in the subgrade shall be excavated and spread evenly on the site. The excavation shall be filled with Granular C or non-frost susceptible native material compacted to 100% Standard Proctor Density.

.7 Soft or contaminated areas of sub-base or base should be excavated and replaced with new material compacted to 100% Standard Proctor Density.

3.2 WINTER GRADING OF GRANULAR

.1 All ice and snow shall be removed from all portion of the Work Area. Frozen material shall not be incorporated into the Work. Material shall not be placed

over frozen ground, except, at the Contractor's option, a single lift may be placed over frozen ground; in which case, final grading and compaction shall be done after the underlying material has thawed.

3.3 COMPACTION

.1 All material within the site shall be compacted to the satisfaction of the Consultant.

.2 All material shall be spread upon the site in loose layer not exceeding 150mm in thickness.

.3 Minimum allowable compaction requirement is 98% Standard Proctor Density.

3.4 TOLERANCES

.1 The surface of the uppermost layer of granular material shall be bladed, shaped and compacted to produce the specified grade and cross-section.

.2 The finished granular course shall not deviate more than 30mm from the specified grade and cross-section and the surface shall not deviated more than 15mm at any place as measure in any direction with a 3m straight edge.

END OF SECTION

1 General

1.1 **GENERAL INSTRUCTION**

.1 All construction to be carried out in accordance with the most current design criteria, standard, and specifications of the City of Toronto, Ontario Provincial Standard Specifications (OPSS), and Ontario Provincial Standard Drawings (OPSD).

1.2 **REFERENCES**

.1 Canadian Standards Association (CSA).
- .1 Current CAN/CSA-A23.1, Concrete Materials and Methods of Concrete Construction.

.2 American Society for Testing and Materials (ASTM).
- .1 Current ASTMD698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft3) (600kN-m/m3).
- .2 ASTM C979 - Pigments for Integrally Coloured Concrete

.3 Ontario Provincial Standard For Roads and Municipal Services, Volume 1 – Section 353 – Construction Specification for Concrete Curb and Gutter Systems

.4 Ontario Provincial Standard For Roads and Municipal Services, Volume 1 – Section 904 – Construction Specification for Concrete Structures

.5 Ontario Provincial Standard For Roads and Municipal Services, Volume 2 – Section 1308 – Material Specification for Joint Filler in Concrete

.6 Ontario Provincial Standard For Roads and Municipal Services, Volume 2 – Section 1315 – Material Specification for White Pigmented Curing Compounds for Concrete

.7 Ontario Provincial Standard For Roads and Municipal Services, Volume 3 – Drawings for Road, Barriers, Drainage, Sanitary Sewers, Watermains and Structures

1.3 **SCOPE OF WORK**

.1 Provide materials, labour and equipment for cast-in-place concrete as shown on the Drawings, described herein, or as necessary to finish the work – including the following:
- .1 Normal concrete work

1.4 **COLD WEATHER CONCRETING**

.1 Between November 1st and April 15th, provide temporary plant and equipment for heating concrete materials and forms. Maintain the proper temperature and humidity of the concrete during curing to CSA-A23.04. Contractor to include for

any winter heat and weather mixes and winter protection required to accommodate schedule.

1.5 **HOT WEATHER CONCRETING**

.1 Comply with CSA-A23.1.04. Take necessary precautions when air temperature exceeds 26°C.

1.6 **MOCK UP SAMPLE AND SHOP DRAWINGS**

.1 If required, provide one 1m x 1m mock-up of concrete sample complete with all finishes for review and approval by Consultant. Provide samples for all concrete types.

.2 Sample to be maintained on site until such time as all concrete work is completed to the satisfaction of the consultant.

.3 Samples are to receive colour and finish treatment and are to be representative of the finish product. Sample panels shall be poured to permit a minimum two (2) week curing and review period prior to the actual pour on site.

.4 Any work not meeting the standards of the approved sample or the specifications herein shall be corrected by the Contractor at his own expense.

.5 Should the Contractor proceed to install CIP concrete contrary to the sample, specifications or standard details, the Consultant shall have such works corrected at the Contractor's expense.

.6 Submit three copies of shop drawings, falsework plans, shoring plans, placing diagrams, bar lists and erection diagrams, all for review by the Consultant.

.7 Provide specific drawings, correctly sealed, identified, signed, dated and bearing the seal of a professional engineer licensed to practice in the Province of Ontario.

1.7 **PRODUCT DELIVERY, STORAGE AND HANDLING**

.1 Review site access routes, storage areas for approval by the Consultant prior to delivery of materials to the site. Stockpile materials in approved locations designated by the Consultant.

.2 The Contractor shall comply with all provincial regulations and the requirements of the MOE, MTO, the City of Toronto, and any other authority having jurisdiction over the Work.

.3 The Contractor will be responsible for any damage to public and/or private property that may be incurred.

.4 Clean all concrete trucks and equipment at a Contractor owned location setup for such a purpose or designate a location on site that is to be paved for cleaning

out concrete trucks. Protect all areas used for cleaning from any environmental effects. No cleaning of trucks or equipment will be permitted in other areas of the site than those approved.

.5 Use trigger operated spray nozzles for water hoses.

.6 Designate a cleaning area for tools to limit water use and prevent runoff.

.7 Prevent plasticizers, water-reducing agents and air-entraining agents from entering drainage facilities or streams. Using appropriate safety precautions, collect liquid or solidify liquid with an inert, non-combustible material and remove for disposal. Dispose of all waste in accordance with MOE, applicable local, provincial and federal regulations.

.8 Ensure emptied containers are sealed and stored safely for disposal.

.9 No storage of equipment or material will be permitted upon existing roads, parking lots or other existing hard surface areas, within or adjacent to the construction site unless approved by the Consultant.

.10 It is the Contractor's responsibility to examine the Place of Work and satisfy himself, by careful examination as to all issues affecting his access to the site and review same with the Consultant before starting work. The Contractor shall avoid any wet areas in accessing the site.

.11 The Contractor under no circumstances or occasion shall claim additional monies as a result of any misunderstanding or lack of information relating to site access. Organize and carry out all operations to prevent damage to the site and the site access including modifications and adjustments to construction methods.

.12 Where the site for the work involves travel across areas not designated for construction the Contractor shall reduce delivery loads and utilize vehicles or equipment of sizes suitable for the work and the conditions. All costs with respect to site access and provision of labour, equipment and materials to construction sites to prevent damage to areas of travel or areas of access including adjustments to reduce or lighten the Contractor's construction methods and equipment are to be included in the appropriate section of the Schedule of Contract Items and Prices bid. The Contractor is responsible, at his own cost, for rectifying any damage caused in gaining access to the site or in the course of carrying out any of the work.

1.8 **QUALITY ASSURANCES**

.1 The Contractor must have a minimum 5 years experience in the construction of concrete pavements and landscape concrete features of a similar nature as specified for the project.

.2 Concrete shall be supplied from a Ready Mixed Concrete Supplier certified by the "Ready Mixed Concrete Association of Ontario".

.3 Provide certification that mix proportions selected will produce concrete of quality, yield and strength as specified in concrete mixes, and will comply with CAN/CSA-A23.1-00/A23.2-00.

.4 The Contractor is responsible for the supply of all mix designs in accordance with the specifications.

.5 Obtain approval from the Consultant of site layout, sub-grade levels and alignment required for the execution of the work including grade stakes indicating finished elevations on the site, layout of all false work, reinforcing and concrete surfaces.

.6 Inspection and compaction tests of sub-grade, sub-base materials and concrete materials will be carried out by an independent testing laboratory. Costs of tests will be paid for by the Contractor. Compaction tests of the sub-grade and sub-base materials must be submitted to the Consultant for approval at each stage prior to proceeding to each subsequent stage.

.7 If requested, minimum 2 weeks prior to starting concrete work, submit to the Consultant certification by qualified independent inspection and testing laboratory naming the products and materials proposed to be incorporated into the work by the Contractor and that they will meet specified requirements for:

.1 Portland cement;
.2 Blended hydraulic cement;
.3 Supplementary cementing materials;
.4 Grout;
.5 Admixtures;
.6 Colour mixes, finishes and types;
.7 Aggregates;
.8 Water;
.9 Water-stop joints;
.10 Expansion joints.

.8 If requested, construct a full-scale mock-up panel (complete with finish as indicated and specified) at least one month before start of other concrete work to allow concrete to cure before observation. Obtain the Consultant approval prior to proceeding. The sample panels or mock-ups will be used to determine the final finishing techniques and quality requirements, colours and must be approved by the Consultant. Accepted mock-up to be standard for all on site work. Mock-up to remain as part of work if accepted. All work to conform to that of the approved sample.

.9 Minimum 2 weeks prior to starting concrete work, submit proposed quality control procedures for the Consultant approval for following items:

.1 False work erection;
.2 Hot weather concrete;

.3 Cold weather concrete
.4 Curing;
.5 Finishes;
.6 Colour additives
.7 Formwork removal;
.8 Joints and sealants

.10 Any work not meeting the standards of the approved sample or the specifications herein shall be corrected by the Contractor at his own expense.

2 Products

2.1 **MATERIALS**

.1 Coloured additive where indicated: Interstar Pigments, Admixtures and Fibers. Colour: Bamboo, JN4411R., 1 bag. Contact: 800 567 1857.

.2 Hydromedia pervious concrete by Lafarge or approved equal. Contact: Innocon, Bahee Sooriyakumar. 647 228 9009.

.3 Portland cement: To CSA-A5-98, Type 10, Normal.

.4 Mixing water: To CSA-A23.1-04.

.5 Fine aggregate: Natural sand: To CSA-A23.1-04.

.6 Construction Specification for Concrete Pavement and Base – OPSS 350

.7 Coarse aggregate: Crushed stone or gravel: To CSA-A23.1-04, OPSS 1004 and OPSS 1010. Maximum size 20mm.

.8 Pre-moulded Joint Filler: Bituminous impregnated fibre to ASTM D1751-83; thickness and depth as shown on drawings.

.9 Pre-mixed non-metallic non-shrink grout: Minimum strength 40 MPa at 28 days. Joint Sealants: Lithoseal Trafficalk – 3G or equal.

.10 Formwork; MDF, nominal wood members,

.11 Falsework Materials: to CSA S269.1-1975.

.12 Steel Reinforcing Bars: To applicable CSA G30.18-M92 (R2002). Use deformed bars, unless noted otherwise on the Drawings. Provide bar supports as required by Manual of Standard Practice of the Reinforcing Steel Institute of Ontario. For exposed concrete locations, use plastic, precast concrete, or plastic protected steel supports. Fabricate reinforcing to CSA A23.1-04. Reinforcing bars: to CAN/CSA-G30.18-[M92], Grade [400].

.13 Flatwork shall be fiber reinforced. Fibres: fibrillated virgin polypropylene, 51 mm long, white colour.

.14 Super-plastizer: to CAN3-A266.2-M78.

.15 Joint sealer/filler: Water proof where indicated with backer rod. Joint sealer in flatwork to match colour of adjacent concrete. Provide sample with sample panel work.

.16 Concrete Sealer: Decra–Seal Cure and Seal as manufactured by WR Meadows or approved equal.

.17 Co-operate with other trades on concrete related work. Give other trades all information regarding materials or items supplied by this trade and affecting work of other trades.

.18 Curing compound shall be with pigmented Type 1, Class B curing compound according to ASTM C309 and be approved by colour manufacturer.

.19 Non-staining mineral type form release agent: chemically active release agents containing compounds that react with free lime to provide water soluble soap.

.20 Tactile Warning Plates:

.1 Product: 4984-36Q- Neenah Foundry Detectable Warning Plates
Material: Cast gray iron units w/ untreated, natural finish
Dimensions: Quick Connect Plates: 610mm (D) x 914mm (W)
Note: Provide shop drawings for each tangent plate layout
Supplied by: Landmark by Crozier
Contact: Aaron Gilmour - aaron.gilmour@crozier.ca; tel 416.648.9232
Quantity: 15 (610mm x 914mm)

.2 Product: 4984-20R Neenah Foundry Detectable Warning Plates
Material: Cast gray iron units w/ untreated, natural finish
Dimensions: Radius Plates: 610mm (D) x 508mm (R)
Note: Provide shop drawings for each radius indicating radius and tangent plate layout
Supplied by: Landmark by Crozier
Contact: Aaron Gilmour - aaron.gilmour@crozier.ca; tel 416.648.9232

2.2 MIX DESIGN

.1 To CSA-A23.1-04 proportioned in accordance with OPSS

.2 Concrete walkways, curbs and gutters
.1 Class of Exposure C-2
.2 Minimum compressive strength at 28 days of 32MPa

.3 Slump Range Pre Plasticized - 40mm +/- 20mm, Post plasticized 120mm +/- 30
.4 Maximum water cement ratio 0.40
.5 Air content 5% to 8%
.6 Maximum size of course aggregate 20mm
.7 Placement – Bucket, Pump/ Telebelt
.8 Use water reducing agents throughout
.9 Wet cure for 3 days - Do not use curing compounds. Concrete Set Normal
.10 Finish – light broom finish; no tooling at sawcut and expansion joints
.11 Fibre-reinforced

.3 C.I.P. Permeable Parking Lot
.1 Class of Exposure C-2
.2 Minimum compressive strength at 28 days of 32MPa
.3 Slump 150mm
.4 Maximum water cement ratio 0.40
.5 Air content minimum 20%
.6 Maximum size of course aggregate 14mm
.7 Placement – Bucket, Pump/ Telebelt
.8 Use water reducing agents throughout
.9 Cover with thin plastic sheeting within 20 minutes of laying and allow to cure for 7 days - Do not use curing compounds. Concrete Set Normal
.10 Hydromedia product by Innocon is acceptable or approved equal

3 Execution

3.1 LAYOUT

.1 Contractor will be responsible for horizontal and vertical layout in the field. Receive approval of layout from Consultant prior to proceeding with construction.

3.2

3.3 REJECTED WORK

.1 Deliver only materials conforming to specified requirements. Remove immediately if rejected after delivery.

3.4 FORMWORK CONSTRUCTION

.1 Construct formwork to obtain concrete surface specified. Design of formwork to comply to OHSA requirements.

.2 Make forms tight and flush faced to prevent mortar leakage, fins or panel outlines.

.3 Apply form coating and release agent to contact surface of formwork panels before first use and before each reuse. Seal lumber in forms for architectural concrete prior to use. Apply form coating uniformly to surfaces.

.4 Use internal form ties. Locate ties in a uniform pattern to the Consultant's approval.

3.5 **GRADE PREPARATION**

.1 Complete preparation work in accordance with Section 31 22 13 – Rough Grading

3.6 **REMOVAL OF FORMWORK**

.1 Be responsible for structural safety before placing, during placing and after approval of forms. Retain forms and supporting shores in place until members are self-supporting and superimposed construction loads may be applied without excessive deflection or distortion. Retain formwork, exclusive of shoring, until concrete attains 75 % of the design strength or minimum period noted in 3.2 of Concrete Forming specification.

3.7 **PLACEMENT OF REINFORCING**

.1 Store reinforcement on racks and skids to protect from dirt and to retain the fabricated form.

.2 Before placing, remove loose scale, dirt, oil or other coatings liable to impair bond. Place reinforcement within specified tolerances and secure in position with chairs, spacers and hangers.

.3 Fabricate, place and cover reinforcing steel to CSA-A23.1-04.

.4 Do not field bend reinforcing.

.5 All flatwork to be fiberglass reinforced.

3.8 **ANCHOR BOLTS AND ANCHOR ASSEMBLIES:**

.1 Anchor bolts - ASTM A307 quality;

.1 Angle Plates and Steel Support Brackets - hot dip galvanized.

.2 Water: to CAN/CSA A23.1/A23.2-00 and OPSS 1302.

.3 Masking Tape: Industrial grade for the intended exterior uses. Sizes as required by the detail drawings. UV and sunlight resistant. Moderately aggressive adhesive that will withstand mechanical wearing will not leave residue on surfaces and permits clean removal. Flexible and able to conform to irregular surfaces.

3.9 **INSERTS**

.1 Set sleeves, ties anchor bolts, pipe hangers, inserts and form openings in concrete floors and walls, as required by other trades. Sleeves, openings, etc.

greater than 100x100 mm and not indicated on structural drawings require the Consultant's approval.

.2 Do not eliminate or displace reinforcement to accommodate hardware. If inserts cannot be located as specified, obtain the Consultant approval of modifications before placing concrete.

3.10 **FOOTINGS**

.1 Founding elevations, based upon the report of the sub-surface investigation, at which it is presumed these conditions pertain are shown.

.2 Founding elevations must be verified by the sub-surface investigation firm before footings are placed.

.3 If, upon excavating to the elevations shown, the required soil conditions are not fulfilled, or if they are fulfilled at a higher elevation, the *Consultant will provide instructions as to how to proceed.

.4 Keep a record of footing founding elevations.

.5 Construct footings in a particular area commencing from the lowest footing elevation and proceeding to the higher elevation.

.6 Proceed in a similar manner for continuous footings to walls which vary in founding elevation by commencing with the continuous footing at the lowest elevation.

.7 Remove water, disturbed soil or foreign matter from footing excavations before placing concrete. Do not permit the soil at founding elevations to soften due to the presence of water in the excavations or construction activity.

.8 Remove water, loose rock or foreign matter from footing excavations before placing concrete.

.9 Note the report of the sub-surface investigation states that the soil is frost susceptible. During cold weather conditions, carefully protect footing bases from frost since the will weaken quickly on exposure to freezing and thawing temperatures.

.10 During cold weather, prevent soil adjacent to and beneath all footings from freezing. Do not pour footings on frozen soil on soil which has been allowed to freeze and thaw. If the soil at specified founding elevations is frozen or was frozen and thawed, remove affected material and found footings on unaffected soil with the required characteristics at no extra cost to the Owner.

.11 During cold weather, prevent rock adjacent to and beneath all footings from freezing.

3.11 **PRODUCTION OF CONCRETE**

.1 Use mixed-in-transit concrete.

.2 Concrete to be vibrated to reduce any air bubbles.

3.12 **NON – SHRINK GROUT**

.1 Premixed compound consisting of metallic aggregate, cement, water, reducing and plasticizing agents, of pouring consistency, capable of developing compressive strength of 45 MPa at 28 days.

3.13 **GRANULAR BASE**

.1 Obtain the 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 to at least 98% of maximum density to ASTMD698.

3.14 **CONCRETE**

.1 150mm concrete barrier curbs shall be constructed in accordance with OPSD 600.110.

.2 Curb depression shall be constructed in accordance with OPSD 600.110.

.3 250mm concrete barrier curbs shall be constructed in accordance with OPSD 3120.100 Type I

.4 150mm concrete curb inlet shall be constructed as per details in Contract drawings

.5 Concrete shall not be placed until the base course on which the concrete is to be placed, and the forms have been inspected by the Consultant.

.6 Prior to placing concrete, the Contractor shall wet down the subgrade immediately ahead of the concrete placing by means of a uniform spray of water sufficient to wet the subgrade thoroughly without leaving standing water.

.7 The concrete shall be placed and compacted in a manner such that segregation of the aggregate does not occur.

.8 Concrete shall be placed continuously and contact with partially set concrete shall be avoided. When placement of concrete is interrupted, it shall be at a vertical form.

.9 A 5mm bituminous fibre joint filler shall be placed before recommencing placement of concrete.

.10 The concrete shall be thoroughly consolidated against all formwork and all entrapped air shall be eliminated.

.11 The concrete curbs and gutters shall be poured to the line and grade (levels) specified on the Contract drawings.

.12 For extruded concrete curbs and gutters, a contraction joint shall be draw tooled a minimum of every 5 metres. The joint shall be a minimum 50mm deep and shall be cut within 12 hours of the concrete set. Failure to follow this procedure will result in the Contractor being entirely responsible for the repair of all shrinkage cracks.

.13 Back edges shall be rounded by use of a 10mm radius edging tool. Neat cement shall not be used as a drier to facilitate finishing.

.14 Any honeycombed areas occurring along the formed surfaces shall be filler with mortar composed of one part Portland cement, and two parts sand with 12% of entrained air.

.15 Concrete curbs and gutters shall be cured using a curing compound.

.16 Concrete curbs and gutters shall be backfilled within 24 hours of the concrete set

.17 Slip-form pavers equipped with string line system for line and grade control may be used if quality of work acceptable to the Consultant can be demonstrated.

3.15 **CONCRETE FINISHING**

.1 Finishing of the concrete surface shall take place while the concrete is sufficiently plastic to achieve the desired grades, elevations, and texture.

.2 The surface of the concrete shall be uniform, dense, free from undulations and projections, struck off true to grade and cross-section, and finished with a float.

.3 Excessive fines and water shall not be drawn to the surface.

.4 Surface evaporation retardants shall not be used as an aid for finishing concrete.

.5 The application of water, cement, or combination of both to the concrete surface shall not be permitted as a finishing aid.

.6 Localized defects shall be repaired using concrete.

.7 The presence of footprints or other marks in the completed sidewalk shall require sawcutting, removal, and replacement of the complete sidewalk bay.

.8 Finish to be light broom without margins unless otherwise noted.

3.16 **EXPANSION AND CONTRACTION JOINTS**

.1 Install tooled transverse contraction joints after floating, when concrete is stiff, but still plastic as per applicable detail. Contraction joints to be minimum 1/3 depth of concrete paving. Receive approval from Consultant in field for final placement of contraction joints/sawcuts.

.2 Install expansion joints as per applicable detail and as shown on drawings.

.3 Install expansion joints around manholes and catch basins and along length adjacent to concrete curbs, catch basins, buildings, or permanent structure.

.4 When sidewalk is adjacent to curb, make joints of curb, gutters and sidewalk coincide.

.5 Install joint filler in expansion joints as per applicable detail.

.6 Use break-away plastic cap, SNAP-CAP expansion joint cap, by W.R. Meadows Inc. or approved equal, sized (10mm or 12mm) to cover all Flexell joint filler or bituminous board material. Seal as per specifications.

.7 Prior to sealing expansion joints clean and blow clean with compressed air. If Break-away SNAP-CAP plastic cap is used, remove cap prior to applying joint sealant. Immediately seal joints following cleaning.

.8 Seal joints no sooner than 30 days following concrete placement.

3.17 **CURING**

.1 Curing should commence as soon as final set has occurred and before the surface starts to dry. Apply concrete curing compound in accordance with manufacture’s written instructions.

.2 Apply curing compound at consistent time for each pour to maintain close colour consistency.

.3 Immediately after placing, protect concrete from premature drying, sunshine exposure, excessively hot or cold temperatures and mechanical injury. Maintain at a relatively constant temperature during proper hydration of cement in the concrete. Keep moisture loss to a minimum.

.4 Cure concrete by adding moisture continuously in accordance with CAN/CSA-A23.1 to exposed finished surfaces for at least 1 day after placing, or sealing moisture in by curing compound approved by the Consultant.

.5 Where burlap is used for moist curing, place two prewetted layers on concrete surface and keep continuously wet during curing period.

.6 Apply curing compound evenly to form continuous film in accordance with manufacturer's requirements.

3.18 **BACKFILL**

.1 Allow concrete to cure for 7 days prior to backfilling.

.2 Backfill to designated elevations with adjacent material as detailed. Compact and shape to required contours as indicated on drawings.

3.19 **TACTILE WARNING STRIP**

.1 Install as per manufacturer's instructions.

3.20 **TOLERANCES**

.1 The exposed surfaces of the finished concrete shall be such that when tested with a 3m long straight edge placed anywhere along the surface parallel to the edge, there shall be no deviation greater than 3mm between the bottom of the straight edge and the surface of the concrete nor shall there be any deviation from alignment in excess of 3mm.

3.21 **FIELD SAMPLING AND TESTING**

.1 Co-operate fully with the testing agency and provide information, access and personnel as required and as directed.

.2 The Inspection/Testing Allowance in Section 01 21 00 Allowances, is to be expended as per this section.

.3 Schedule and co-ordinate work and notify the Consultant and the Testing/Inspection Agency at least 48 hours prior to the completion of each stage in order that timely arrangements can be made for inspection, review and testing.

.4 The Contractor is advised and cautioned to fully satisfy himself, prior to notifying the Consultant and testing agency, as to the state of readiness of the work. All costs incurred due to false or premature notification shall be solely borne by the Contractor, as the Consultant will not authorize reimbursement of same.

.5 Concrete testing by an independent agency shall be complete in all respects, including the following main items:

.1 A standard strength test for each 15 m3 (20cy) of concrete placed but at least one test for concrete placed each day. Each strength test sample will consist of three cylinders with proper identification and field data. One specimen will be tested at 7 days and two at 28 days. Cylinders will be stored in metal lined curing boxes at a temperature of +10ºC until shipped to the testing laboratory.

.2 One standard air entrainment test for each standard strength test.

.3 One or more standard slump tests with each standard strength test.

.4 Tensile capacity tests perpendicular to the plane of the interface. Tests subsequent to any failure shall be paid for by the Contractor. Bond strength shall be at least 1.00 MPa (145 psjg).

.6 Testing by an independent inspection and testing agency will not augment or replace Contractor quality control, nor relieve him of his contractual responsibilities.

.7 Concrete testing shall be done by personnel certified the American Concrete Institute at the level of Concrete Field Testing Technician, Grade 1 or by personnel from a testing company certified by the Canadian Standard Association, CSA A283 Category O. Personnel from the CSA certified company shall have passed the CSA examination in concrete field testing that is required for certification.

.8 The plastic concrete shall be sampled and field tested for slump, air content and temperature in conformance with OPSS 1350 and the results of these tests recorded.

.9 The air meter shall be calibrated at least once a year in conformance with CSA 23.2-4C and the certificate shall be available when requested.

.10 The minimum frequency of testing shall be occurred three (3) sets a day and the samples of the load shall be taken directly from the load of concrete as directed by the Consultant.

.11 The concrete test cylinders shall be made and cured in conformance with CSA Test Method A.23.2-3C for compressive tests to be performed by the Owner.

.12 The cylinders shall be formed in moulds. When sheet metal moulds are used they shall be enclosed in polyethylene bags closed with twist ties immediately after moulding.

3.22 **CLEAN-UP**

.1 Daily: scrape up and remove concrete droppings and debris.

.2 At completion; remove formwork, accessories and debris. Leave premises in a ‘broom-clean’ condition.

.3 Make good all damage to other work resulting from concrete work.

END OF SECTION

1 General

1.1 **CONFORMANCE**

.1 The General Conditions, Supplementary Conditions and the Requirements of Division 1, are part of this Section and shall apply as if written here.

1.2 **DESCRIPTION OF WORK**

.1 The extent of the precast paver work is as shown on the drawings and/or as specified herein.
.2 Laying pattern as shown on construction drawings.

1.3 **REFERENCES**

.1 CAN/CSA A23.1-M90, Concrete Materials and Methods of Construction, Section 5.3.2.

.2 CSA-A231.2-95, Precast Concrete Pavers.

2 Products

2.1 **MATERIALS**

.1 Granular Base Course: In accordance with specified requirements of OPSS Specifications 1010.

.2 Base Course: As per details

.3 Physical requirements of pavers:
.1 Compressive Strength: At the time of delivery to the work site, the average compressive strength shall not be less than 55 Mpa. Testing procedures shall be in accordance with ASTM C 67
.2 Absorption: The average absorption shall not be greater than five percent (5%) with no individual unit absorption greater than seven percent (7%) as required by ASTM Specification C-936-82.
.3 Resistance to Freezing and Thawing: The manufacturer shall satisfy the purchaser either by proven field performance of a laboratory freezing and thawing test that the paving units have adequate resistance to freezing and thawing. If a laboratory test is used, when testing in accordance with Section 8 of Method C67, specimens shall have no breakage and not greater than 1.0% loss in dry weight of any individual unit when subjected to 50 cycles of freezing and thawing.

.4 Unit pavers:

.1 Ground level (Infant and Toddler Playground):

.1	Base Course:	Per Detail, verify with Consultant
.2	Paver:	Unilock Series
.3	Pattern:	'A'
.4	Colour/ Finish:	Golden Sand
.5	Size:	40% Large Rect., 20% Small Rect., 40% Square
.6	Joint fill:	Polymeric sand
.7	Manufactured by:	Unilock
.8	Or approved equal	

.2 Rooftop (Preschool Playground):

.1	Base Course:	Per Detail, verify with Consultant
.2	Paver:	Thin Paver
.3	Pattern:	Grid
.4	Colour/ Finish:	Tan Creek LP11, River Series
.5	Size:	600mm x 600mm
.6	Joint fill:	HPB
.7	Manufactured by:	Tectura Designs by Wausau Tile Inc.
.8	Contact: Chris Duncan, wausaunortheast@gmail.com,	
.9	Or approved equal	

.3 Rooftop (Preschool Playground):

.1	Base Course:	Per Detail, verify with Consultant
.2	Paver:	Thin Paver
.3	Pattern:	Grid
.4	Colour/ Finish:	Seagrass LP33, Coastal Series
.5	Size:	600mm x 600mm
.6	Joint fill:	HPB
.7	Manufactured by:	Tectura Designs by Wausau Tile Inc.
.8	Contact: Chris Duncan, wausaunortheast@gmail.com,	
.9	Or approved equal	

.5 Roof Top Drainage Mat (same as drainage mat under rubber tiles):

.1 10mm deep drainage mat DBV 10 by Zinco Canada Inc. PO. Box 29, Carlisle, ON L0R 1H0. Contact: Jeremy Wright, telephone 905 690 1661, JWright@zinco.ca.

.6 Aluminum Edging (Rooftop):

.2 Gravel Retainer KL 60/80 by Zinco Canada Inc. PO. Box 29, Carlisle, ON L0R 1H0. Contact: Jeremy Wright, telephone 905 690 1661, JWright@zinco.ca.

.7 Bedding Material:

.1 to CSA A23.1-M94. Sieve according to CSA – A23.2A, clean, sharp and free of deleterious material or other contaminants likely to cause efflorescence.

.2 Base layer shall be of uniform moisture content when screed and shall be protected against rain when stock piled on site prior to screening.
.3 The moisture content shall be in the range of 4-8 %.

.8 Jointing Material:
.1 for paver joints and setting bed to meet specified requirements to CSA Standard A82.56.
.2 Jointing Material shall be free of organics and soluble salts or contaminants likely to cause efflorescence.
.3 Pavement Sealant as per landscape architect's instructions.

2.2 VISUAL INSPECTION

.1 All units shall be sound and free of defects that would interfere with the proper placing of the unit or impair the strength of permanence of the construction. Hand select only the best stone from the stockpiled material.

2.3 MOCK UP SAMPLE AND SHOP DRAWINGS

.1 If required, provide one 1m x 1m mock-up of unit paving sample complete with all colours and patterns for review and approval by Consultant. Provide samples for all unit paver types.

.2 Sample to be maintained on site until such time as all unit paving work is completed to the satisfaction of the Consultant.

.3 Samples are to receive colour and finish treatment and are to be representative of the finish product.

.4 Any work not meeting the standards of the approved sample or the specifications herein shall be corrected by the Contractor at his own expense.

.5 Should the Contractor proceed to install unit pavers contrary to the mockup sample, specifications or standard details, the Consultant shall have such works corrected at the Contractor's expense.

.6 Submit three copies of submittals including sample and source of unit pavers for review by the Consultant.

3 Execution

3.1 **PREPARATION/PROTECTION**

.1 The area must be stripped of all topsoil unstable or unconsolidated materials to the grades specified.

.2 Take necessary measures to ensure that dust from work of this section is not spread over adjacent areas.

3.2 **SUBGRADE**

.1 All subdrainage or underground services within the pavement area must be completed in conjunction with subgrade preparation and before the commencement of base construction.

.2 Ensure that subgrade preparation conforms to levels required to allow for installation of granular base – must be approved first by Consultant.

3.3 **GRANULAR BASE**

.1 Spread and compact base course in uniform layers minimum 100 mm compacted thickness for concrete sidewalks and 150 mm compacted thickness for interlocking pavers and limestone pavers. Use mechanical tamper for base and subgrade compaction

.2 Sub-base minimum thickness: as indicated on drawing details.

.3 Compact to a density of not less than 98% maximum dry density in accordance with ASTM D697-78.

.4 Shape and roll alternately to obtain a 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, aerate by scarifying with suitable equipment until moisture content is corrected.

.6 In areas not accessible to rolling equipment, compact to specified density with hand tampers.

.7 Ensure top of granular base does not exceed plus or minus 10 mm of finished grade less combined thickness of granular laying course plus surface course.

.8 The upper surface of the base shall be sufficiently well graded and compacted to prevent infiltration of the bedding sand into the base both during construction and throughout its service life.

3.4 CONCRETE BASE

.1 Unit paver concrete base to be a monolithic pour with adjacent concrete paving to eliminate surface differential heaving between surface treatments.

.2 Sub-base minimum thickness: as indicated on drawing details.

.3 Fibre reinforce 32MPa C.I.P. concrete to depth indicated on drawing details.

.4 5-7% Air entrainment in concrete.

.5 Ensure conformity of grades with finish surface.

.6 Ensure top of concrete base does not exceed plus or minus 10 mm of finished grade less combined thickness of granular laying course plus surface course.

3.5 BEDDING LAYING COURSE

.1 Place base course to specified thickness as per detail.

.2 Under no circumstances shall the setting bed layer exceed 50 mm in thickness following compaction of the pavement.

.3 The Owner or Consultant will require compaction tests of subbase. Compaction tests are to be submitted to the Consultant for review and approval prior to proceeding.

3.6 SURFACE COURSE

.1 General:
- .1 Finish pavement surfaces to elevations true to grade, in location, layout and pattern as indicated.
  - .1 Maintain accuracy of elevations to within specified tolerances.
  - .2 Ensure that drainage is achieved from all areas without formation of puddles. Provide minimum slope of 1-1/2 %.
  - .3 Inform Consultant if slopes to drains are less than 1%, or more than 5%, before commencing work in order that corrective methods may be considered.

.2 Placing of stone and pavers on concrete base
- .1 Lay out pavers as indicated on drawings.
- .2 Pattern to be as per drawings and details.
- .3 In order to maintain desired pattern joint spacing must be consistent.
- .4 Recommended spacing approximately 2-4 mm must be maintained.
- .5 Finish pavement surfaces to elevations indicated on drawings.
- .6 Maintain accuracy of elevations to within specified tolerances.

.7 Cut pavers to fit with true sharp edges. Cut stones using masonry saw. The use of infill concrete, concrete “collars” around utilities, or discontinuities in patterns will not be permitted; exceptions are to be verified and approved by Consultant

.8 Pavers cut to fit will not be accepted less than 100mm in length and width. Should such a condition arise, Contractor is to select next adjacent paver and shorten accordingly to allow for the cut-to-fit-paver to be min. 100mm. Contractor is to minimize the condition of small and vulnerable pieces of pavers along edges that will be susceptible to frost heave. Exceptions to be verified and approved by Consultant.

.9 Tamp down and level pavers with rubber mallet or paver's own weight.

.10 Fill spaces between pavers with Polymeric Sand or material indicated on details.

.11 Sweep surface course clean and ensure pavers are not damaged during compaction.

.12 Install edging bed to outside stones and base areas as detailed.

3.7 ADJUSTMENTS AND CLEANING

.1 Replacement of Defective Work

.1 Replace defective concrete sidewalk with patches covering entire area between scored joints.

.2 Replace entire paver units that are defective.

.2 Protection After Completion

.1 Protect paving from vehicular traffic for a period of at least seven (7) days, unless directed otherwise.

.2 Pedestrian traffic shall not be allowed on paving for at least three (3) days, unless directed otherwise.

.3 Be responsible for the repair of all damages until inspected and approved by the Consultant and traffic is allowed onto pavement.

.3 Clean-up

.1 After completion of paving, clean all areas and structures including but not exclusive to curbs, walls, catch basin gratings, manhole covers, etc. from all contamination resulting from paving operations.

END OF SECTION

1 General

1.1 **RELATED WORK**

.1 Section 01 30 00 – Administrative Requirements

1.2 **REFERENCES**

.1 CAN/CGSB-1.5-[M91], Low Flash Petroleum Spirits Thinner.

.2 CGSB1-GP-12c-[68], Standard Paint Colours.

.3 CGSB1-GP-71-[83], Method, of Testing Paints and Pigments.

.4 CGSB1-GP-74M-[79], Paint, Traffic, Alkyd.

1.3 **SAMPLES**

.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit to Consultant following material sample quantities at least 4 weeks prior to commencing work.
.1 Two 1L samples of each type of paint.
.2 One 1kg sample of glass beads.
.3 Sampling to CGSB1-GP-71.

.3 Mark samples with name of project and its location, paint manufacturer's name and address, name of paint, CGSB specification number and formulation number and batch number.

1.4 **MEASUREMENT FOR PAYMENT**

.1 Pavement marking will be measured by lump sum.

.2 Pavement marking including reflective glass beads will be measured by lump sum.

.3 Supply of paint will be measured in litres.

.4 Symbols and letters will be measured in units.

2 Products

2.1 **MATERIALS**

.1 Paint: StreetBond by Hub Surface Systems. Contact; Doug Bain, doug.bain@hubss.com.

.2 Colour: Avocado

3 Execution

3.1 **EQUIPMENT REQUIREMENTS**

.1 Paint applicator to be an approved pressure type [mobile] distributor capable of applying paint in single, double and dashed lines. Applicator to be capable of applying marking components uniformly, at rates specified, and to dimensions as indicated, and to have positive shut-off.

3.2 **CONDITION OF SURFACES**

.1 Pavement surface to be dry, free from ponded water, frost, ice, dust, oil, grease and other foreign materials.

3.3 **APPLICATION**

.1 Pavement markings according to layout provided in drawings.

.2 Unless otherwise approved by Consultant, apply paint only when air temperature is above 10 degrees Celsius, wind speed is less than 60km/h and no rain is forecast within next 4h.

.3 Apply traffic paint evenly at rate of $3m^2/L$.

.4 Do not thin paint unless approved by Consultant.

.5 Symbols and letters to conform to dimensions indicated.

.6 Paint lines to be of uniform colour and density with sharp edges.

.7 Thoroughly clean distributor tank before refilling with paint of different colour.

3.4 **TOLERANCE**

.1 Paint markings to be within plus or minus 12 mm of dimensions indicated.

.2 Remove incorrect markings in accordance with manufacturer's recommendations.

3.5 **PROTECTION OF COMPLETED WORK**

.1 Protect pavement markings until dry.

END OF SECTION

1 General

1.1 **RELATED SECTIONS**

.1 Section 01 30 00 – Administrative Requirements

.2 Section 33 46 16 – Landscape Drainage

.3 Section 03 30 00 – Cast-in-Place concrete

1.2 **REFERENCES**

.1 CSA-Z614-2014 Children's Playspaces and Equipment.

.2 CAN/CSA-B651-04 Accessible Design for the Built Environment.

.3 ASTM F-1292-99 or EN: 1177:1997 to be congruent with CSA Z614.

.4 ASTM F2075 Specification for Engineered Wood Fibre for Use as a Playground Safety Surface Under and Around Play Equipment.

.5 ASTM F1951 Standard Specification for Determination of Accessibility of Surface Systems Under and Around Play Equipment.

.6 CPSC - U.S. Consumer Product Safety Commission - A Handbook for Public Playground Safety, Volume II: Technical Guidelines for Equipment and Surfacing.

.7 UL 94 Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances Testing, Underwriters Laboratories.

.8 Consumer Products Safety Commission (CPSC)

.9 Material Specifications for Aggregates - Miscellaneous OPSS 1004

.10 Material Specifications for Aggregates - OPSS 1010

1.3 SCOPE OF WORK

.1 This section describes the work and materials associated with the installation of protective rubber surfacing within the playground environment.

.2 Furnish all labour, materials and equipment necessary to construct playground safety surfaces with in accordance with the lines, grades, levels and dimensions shown on the drawings and in accordance with the construction details and specifications herein.

1.4 SUBMITTALS

.1 Samples of the following for approval by the Consultant.

.1 150mm x 150mm (6” inch x 6” inch) beveled samples of the 600mm (2-1/2”) safety surface.

.2 Certified Test Data that Safety Surfacing meets or exceeds the following:

.1 ASTM F–1292 Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment.
.2 CAN/CSA–Z614 Standards on Childrens’ Playspaces

.3 Submit written statement, signed by safety surfacing installer stating that Drawings and Specifications have been reviewed by qualified representatives of materials manufacturer, and that they are in agreement that materials and system to be used for safety surfacing are proper and adequate for applications shown.

.4 Substrate Acceptability: Submit a certified statement issued by manufacturer of Safety Surfacing materials and countersigned by applicator, attesting that areas and surfaced designated to receive safety surfacing have been inspected and found satisfactory for reception of work covered under this Section: and are not in conflict with “Warranty” requirements. Application of materials will be constructed as acceptance of surfaces.

.5 Statement of Supervision: Upon completion of Work, submit a written statement signed by manufacturer stating that field supervision of manufacturer’s representative was sufficient to insure proper application of materials, which

Work was installed in accordance with Contract Documents, and that installation is acceptable to manufacturer.

1.4 QUALITY ASSURANCE

1. The Contractor is to ensure that the sub-grade and preparatory work in advance of the safety surface has been reviewed by Consultant before placing the safety surface.

2. Inspection and compaction tests of sub-grade, sub-base materials or the supporting base components will be carried out by an independent testing laboratory. Costs of tests will be paid for by the Contractor. Compaction tests of the sub-grade and sub-base materials or the supporting base components must be submitted to Consultant for approval prior to the installation of the Rubber safety surface.

3. Installer shall have at least 5 years proven experience in the industry and be approved by the product manufacturer.

4. The contractor must provide a safety surface testing consultant for all surface impact testing complete with GMAX and HIC scores.

1.5 MATERIAL TESTING

.1 Weathering: After being subjected to a freeze-thaw cycle in accordance with ASTM C 67 and after being subject 200 Degrees F for seven days in accordance with ASTM D 573, the sample shall be retested in compliance with ASTM F-1292 at 72 Degrees F only. A peak deceleration rereading not exceeding 200 G's shall be maintained.

.2 Slip Resistance: Wet dynamic reading shall not be less than 40 when tested in accordance with ASTM E 303, using British Portable Skid Resistance Tester.

.3 Flammability: Minimum Critical radiant flux of 0.22 Watts/CM2 when tested in accordance with ASTM E 648.

.4 Particulate Rubber Particles must successfully pass ASTM standard CFR 1630 for flammability of carpet and rugs.

1.6 WARRANTY:

.1 Provide a written warranty stating that work executed under this Section will be free from defects of materials and workmanship for a minimum period of two years from date of Substantial Completion, and that material breakdown and unravelling will be remedied on written notice at no additional cost to the Owner. The Warranty shall be in writing and shall be signed by the Contractor, the Safety Surface materials manufacturer. Warranty shall include removal and replacement of materials as required to repair safety surfacing, at no cost to the Owner.

1.7 **DELIVERY, STORAGE, AND HANDLING:**

.1 All materials for the work of this Section shall be delivered, stored and handled so as to preclude damage of any sort. Materials showing evidence of damage shall not be used and shall be removed from the site.

.2 Materials in manufacturer's unopened containers or bundles must be fully identified with brand, type, grade, date of manufacture, class, lot number, and other qualifying information.

.3 Store materials in original tightly sealed containers or unopened packages. Materials shall be stores out of weather, off the ground, in dry area, in compliance with manufacturer's maximum storage temperature range.

.4 Materials must be delivered and off-loaded by installation personnel.

1.8 **SITE/JOB CONDITIONS:**

.1 Conditions of substrates with respect to structural performance shall be evaluated and approved by the applicator prior to applying the safety surfacing.

.2 Surfaces are to be installed only when temperatures and weather conditions prior to, during, and after installation will meet manufacturer's requirements.

.3 Maintain manufacturer's current installation instructions at the job site at all times for safety surface material to be used on the Project.

.4 Maintain material storage area at temperatures meeting the manufacturer's requirements.

.5 Proceed with work of this section only after substrate construction and penetrating work have been compacted to 98% of dry density.

.6 Do not proceed with work during inclement weather. Comply with manufacturer's recommendations for application and curing under specific climatic conditions.

.7 Coordinate application of safety surfacing with work of other trades.

1.9 **PROTECTION:**

.1 Protect the safety surface from damage, resulting from spillage, dripping, and dropping of mater. Prevent materials from entering and clogging drains. Repair, restore or replace work, which is soiled or damaged in connection with the performance of the work.

1.10 **GENERAL**

.1 The installation of the Safety Surfacing specified herein and indicated on the Drawings shall be performed by firm who can furnish supporting evidence of installation experience to perform this work and who has regularly been engaged in this work on a full time basis for a period of not less than 5 years.

.2 The installation of the Safety Surfacing shall be performed by an applicator that can furnish evidence of direct employment by the manufacturer.

.3 The installation of the Safety Surface shall be overseen by a factory representative.

.4 Material shall be vandal resistant, firmly secured so that it cannot be pulled away from the playground surface (with the exception of Engineered Wood Fiber).

.5 Installed Safety Surface shall meet or exceed CPSC performance guidelines with respect to the Critical Heights of the proposed in-place play equipment.

.6 Material is used in construction of the Safety Surface System shall be tested for conformance with requirements of Z614-2014 clause 10.1.

.7 Manufacturer must supply preventative maintenance program recommendations along with clear and definitive cleaning instructions of the product supplied.

.8 Manufacturer must be capable of providing a performance bond if required.

1.11 MATERIALS – RUBBER

.1 GENERAL:

.1 All material components of the safety surfacing shall be obtained from the same source, Binder type by name must be verified by customer prior to field installation. No substitutions.

.2 Safety Surfacing shall be installed in the presence of a factory trained service representative to insure the highest quality installation.

.1 Installation of Safety Surfacing shall be over sub-surface as per manufacturer's instructions and as detailed. The safety surfacing in itself shall not create new hazards; hence all installations shall be done as carefully as possible in a neat and workmanlike manner.

.2 Layout of areas of safety surfacing shall be reviewed by the manufacturer's representative to insure that the proper thickness of safety surface is installed.

.3 All work must be protected from vandalism and other damage during the installation.

.2 MATERIALS

.1 Surface consisting of recycled rubber tire granules combined together with a polyurethane binder.

.2 Binder: A binder, approved by the safety surface manufacturer shall be used.

.3 Thinner: A thinner, approved by the safety surface manufacturer shall be used for cleaning tools.

.4 Safety Surface System:

.1 Shall have been tested to provide surface impact test no greater than 161 GMAX and no greater than 800 HIC.

.2 Shall have been tested for non-slip characteristics under ASTM E-303.

.3 Shall have been tested for ease of ignition under BS-5696 and ASTM D-2859.

.4 Shall have been tested for fire resistance under UL94.

.5 Shall contain no latex.

.5 COLOUR MIXES:

.1 EPDM: Teal Colour Mix; 20% Brown, 30% Beige, 50% Teal

.2 EPDM: Forest Green Colour Mix: 20% Brown, 30% Beige, 50% Forest Green
.3 Tile: Light Grey
.4 Tile: Safari Mix
.5 Tile: Aquarium
.6 Roof Top Drainage Mat:
.1 10mm deep drainage mat DBV 10 by Zinco Canada Inc. PO. Box 29, Carlisle, ON L0R 1H0. Contact: Jeremy Wright, telephone 905 690 1661, JWright@zinco.ca.

.3 MIXING AND PREPARATION:

.1 Mixture of binder and Rubber will be determined by the system, which is specified. Verify with manufacturer for specific detailing.

.4 INSPECTION:

.1 Examine areas and conditions where safety surfacing is to be installed and curing of the safety surfaces.

1.12 **CLEANING AND PROTECTION:**

.1 Clean, repair or replace work of trades soiled or damaged by safety surface installation work.

.2 The Contractor shall be responsible for protection of finished surfaces until completion of construction and sign off.

2 Products

2.1 **ACCEPTABLE PROTECTIVE SURFACE MATERIALS**

.1 Ground level (Infant and Toddler Playgrounds):
.1 Protective rubber surface is EPDM Multi-speckled playground rubber,
Acceptable Manufacturer(s):
.1 Acceptable materials are provided by Fortco Synthetic Safety Surfaces, 1190 Old Oak Drive, Oakville, ON L6M 3K7. Contact: Sandro Forte, telephone 416-736-3455 fax 905-825-5887 Email: sandro.forte@sympatico.ca.
OR approved equal.

.2 Rooftop (Preschool Playground):
.1 Protective rubber surface is Rubber Tiles,
Acceptable Manufacturer(s):

.1 Acceptable materials are provided by Tread Bounce, Pliteq, 4211 Yonge St. Suite 400, Toronto, ON M2P 2A9. Contact: Geoff Lavoie, telephone 416-906-2852, email glavoie@pliteq.com
OR approved equal.

3 Execution

3.1 **EXAMINATION**

.1 Examine areas and conditions where safety surfacing is to be installed and curing of the safety surfaces.
.2 Verify that the base, drainage system, site conditions, surfaces are ready to receive work and elevations are as indicated on drawings.

3.2 **PRE-JOB CONFERENCE**

.1 One week prior to placement of concrete, a meeting shall be held to discuss the Project and application methods.

3.3 **INSTALLATION**

.1 Provide safety surface immediately after installing playground equipment.

.2 Safety Surface shall be installed to thicknesses indicated by the manufacturer/installer. Minimum thicknesses indicated must be based on the performance standards of the approved products.
.1 Thicknesses of safety surfacing must meet all safety requirements and codes for fall heights of specified play equipment.

.3 Rooftop Rubber Tiles: to be installed with glue down method as per manufacturers instructions with additional drainage mat as per detail.

3.4 **BASE PREPARATION**

.1 As detailed on contract drawings.

3.5 **INSPECTION**

.1 Examine areas and conditions where safety surfacing is to be installed and curing of the safety surfaces.

3.6 **IN SITU TESTING**

.1 Certify that installed materials meet the latest CAN/CSA-Z614-2014 Standards and requirements for minimum depths related to most stringent fall heights – to meet 161 G-max / 800 HIC minimum measurements.

.2 Confirm in writing that the proposed depths shown on the drawings and installed meet the latest edition of safety requirements listed above, and are suitable for the most stringent (highest) play equipment fall heights for the play equipment specified and installed. A minimum of 1 test for each play structure or each stand alone piece of equipment subject to a fall height requirement is required to confirm that play surface meets the requirements for safety as defined in the CSA standard.

.3 The Contractor will have the product tested by an Independent Testing Consultant, to determine the average G-max and HIC results of the insitu product. If an average G-max over 161 is registered on site, the Contractor shall be required to have lab testing of insitu samples as per ASTMF 1292 to determine the G-max and HIC at no expense to the Owner. Safety Surfacing testing to be included in base bid, not allowance.

.4 All safety surfaces installed in playground applications shall be tested in accordance with the testing requirements of ASTM F1292-99 or the latest version as adopted and endorsed by the CSA Technical Committee related to CAN/CSA-Z614-2014. Any safety surface not meeting the requirements of this specification shall be removed in its entirety and replaced by the Contractor at no cost to the Owner.

.5 Testing of safety surfaces to ensure compliance with this specification shall be completed within 7 days of installation and is required as part of and prior to submission of the City's playground certification form.

.6 Submit site testing report including photos of the test locations to the Consultant within 48 hours of testing.

.7 Safety Surface testing (Playgrounds) – a minimum of 1 test at 3 locations for each play structure or each stand alone piece of equipment subject to a fall height as defined in the CSA standard CAN/CSA-Z614-2014 and the specification herein. Allow for a minimum of 12 tests per site. (Note 1 test = 3 drops at 3 locations for each piece of equipment).

.8 Failure of the laboratory tests will require replacement of the surface to meet specifications and safety requirements at no cost to the Owner.

.9 Upon confirming the safety surface compliance the Contractor shall complete and submit the Playground Certification Form and affidavit to the Consultant.

.10 Include a copy of the Playground Certification Form and Warranty in the project operations manual.

.11 Any installation not tested in accordance with the above or the specifications herein may be subject to removal and reinstallation. All associated costs to correct or to verify the safety surface performance including any removal and reinstallation will be borne by the Contractor

3.7 **PROTECTION**

.1 Protect finished installation in accordance with manufacturer's instructions.

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 Trellis

.2 Playhouse

.3 Sandbox

.4 Fences (Type 1 and Type 3)

.5 Glass balustrades (Fence Type 2)

.6 Play panels

1.2 **RELATED WORK**

.1	Wood decking:	Division 06 15 00
.2	Water play table, mud kitchen, tables and stools:	Section 06 40 12
.3	Earthwork:	Section 31 00 00
.4	Granular base course:	Section 32 11 16
.5	Concrete walks, curbs and gutter:	Section 32 13 15

1.3 **REFERENCES**

.1 CSA A23.1-14 Concrete Materials and Methods of Concrete Construction.

.2 CCSA G40.21-13 Structural Quality Steels.

.3 CSA 08 Series-15 Wood Preservation.

.4 CSA 086-14 Engineering Design in Wood.

.5 CSA 0121-17 Douglas Fir Plywood.

.6 CSA 0151-17 Canadian Softwood Plywood.

.7 CSA W59-13 Welded Steel Construction.

.8 CAN/CGSB-12.1-2017 Safety Glazing.

.9 ASTM C920-18 Standard Specification for Elastomeric Joint Sealants.

.10 OPSS 1860 Material Specifications for Geotextiles.

1.4 **QUALITY ASSURANCE**

.1 Except where otherwise specified herein or otherwise shown on drawings comply with requirements of the following sections when fabricating and installing the work of this section:

.1	Excavation and fill:	Section 31 00 00
.2	Granular base course:	Section 32 11 16
.2	Concrete:	Section 32 13 15
.3	Metal fabrications:	Section 05 50 00
.4	Rough carpentry:	Section 06 10 00
.5	Finish carpentry:	Section 06 20 00
.6	Modified bituminous roofing:	Section 07 52 00
.7	Metal flashings:	Section 07 62 00
.8	Glass and glazing:	Section 08 80 00
.9	Exterior steel coatings:	Section 09 97 13

1.5 **SUBMITTALS**

.1 Submit detailed product data for each product to be used.

.2 Submit detailed shop drawings for glass balustrades, bearing seal and signature of a professional engineer licensed to practice in Ontario.

.3 Submit detailed shop drawings for trellis, bearing seal and signature of a professional engineer licensed to practice in Ontario. Show materials, sizes, connections, anchorages, foundations, reinforcing, bracing and other essential components required to meet OBC requirements (based on OBC climatic information for a 100 year probability).

.4 Submit duplicate, minimum 300 mm long samples of up to four different sizes of wood to be used in exposed locations. Samples shall be coated with specified stain, in colour selected by Consultant.

.5 Submit duplicate minimum 300 × 300 mm samples of play panels, finish coated as specified.

.6 Submit manufacturer’s sample chart of sandbox tarpaulin colours for selection of colour by Consultant.

2 Products

2.1 **MATERIALS**

.1 Metal Components:

.1 Steel sections and plate: CAN/CSA-G40.21-13, Grade 300W.

.2 Steel tubes: CAN/CSA-G40.21-13 Grade 350W, Class H.

.3 All steel components: hot dip galvanized in accordance with CSA W59-13.

.4 Anchors, connectors, bolts, dowels: hot dip galvanized steel.

.2 Wood Components:

.1 Exposed locations: Western Red Cedar kiln dried, surfaced all sides: WRCLA “Custom Clear” and/or “A Clear” grades.

.2 Concealed locations: S-P-F lumber to CAN/CSA-086-14, preservative pressure treated to CAN/CSA-80-Series-15, arsenic free, using copper and azole.

.3 Roof deck: Douglas Fir Plywood to CSA 0121-08, Select Tight Face Grade.

.4 Play panels: medium density overlay (MDO) plywood to CSA 0151-17.

.3 Cast-in-place Concrete:

.1 Steel reinforcing: CAN/CSA-G30.18-M92.

.2 Concrete: CSA A23.1-14, minimum compressive strength of 20 MPa at 28 days.

.4 Glass balustrades:

.1 Glass: 13.5 mm thick laminated tempered clear float glass to CAN/CGSB-12.1-M90; GL10 as specified in Section 08 80 00.

.2 Glazing gaskets, spacers, setting blocks: neoprene or EPDM, black, of hardness recommended by glass manufacturer.

.3 Glazing sealant: one-part silicone, to ASTM 0920.

.5 Paints and stains:

.1 Steel components: as specified in Section 09 97 13; colours selected by Consultant.

.2 Stain: semi transparent matte wood stain Cetol SRD Translucent Wood Finish by Sikkens, colours selected by Consultant.

.6 Fence gate hardware:

.1 Hinges: 25 mm dia. × 100 mm long heavy duty weld-on barrel hinges by ALEKO.

.2 Lockable gate latches: Lokklatch De Luxe Dual Lockable Gravity Latch, Model LLDAB-K by Gokeyless (1-937-247-9327 or sales@gokeyless.com).

.3 Cane bolts: approximately 300 mm high foot bolt with sleeve and strike plate.

.7 Sandbox accessories:

.1 Sand: high quality, tan coloured natural beach sand: KING Play Sand or equivalent product by other source approved by Consultant.

.2 Tarpaulin: Heavy Duty vinyl tarp (18 oz.); colour selected by Consultant.

.3 Tarp securement: Nickel plated brass turn buttons, grommets and backing plate by Northwest Tarp and Canvas.

.4 Filter fabric: non-clogging type to OPSS 1860, Class 1: Terrafix 270R.

.5 Waterproofing membrane: Ice & Watershield by Grace.

.8 Play panels:

.1 “Chalkboard” paint: FolkArt Multi Surface Chalkboard Paint, Black, by Plaid.

.2 Panel hangers: Aluminum concealed mounted hanging system: MFSS Clip by Monarch.

2.2 **FABRICATION**

.1 Fabricate components in shop to largest practicable extent, in accordance with this specification, details shown on drawings and in conformance with reviewed shop drawings.

.2 Provide steel work of welded construction, except where bolted connections are indicated. Welds in exposed locations shall be continuous, ground and polished smooth.

.3 Lumber end grain shall not be visible; mitre external corners, unless otherwise detailed.

.4 Fasteners shall be concealed wherever possible. Where exposed fasteners are unavoidable they shall be recessed or countersunk.

.5 Fabricate tarpaulin for sandbox to extend over perimeter curb and down it on the outside minimum 150 mm. Heat weld intermediate seams. Edges shall be folded/hemmed and stitched. Provide grommets at corners and at maximum 400 mm o.c. in between, and matching locations of turn buttons.

3 Execution

3.1 **EXAMINATION**

.1 Examine existing conditions to ensure that they are acceptable to receive the work of this Section.

.2 Start of installation shall imply acceptance of conditions.

3.2 **PREPARATION**

.1 Prior to start of installation lay out the work as required and obtain Consultant's review and approval.

.2 Coordinate with sections providing surface finishes to ensure proper placement of components.

3.3 **INSTALLATION**

.1 Install components at required locations and elevations, plumb, level and in proper alignment, in accordance with requirements of Contract Documents.

.2 Excavate for required footings to minimum 1.2 m below finish grade. Install sleeves at post locations and where required provide reinforcing and anchor bolts. Place, consolidate and cure cast-in-place concrete. Provide broom finish at slab on grade.

.3 Secure fence posts into sleeves with fast setting non-shrink grout; brace posts in plumb position until grout has set.

.4 Where preservative pressure treated lumber has been cut, drilled or otherwise worked, apply heavy coat of liquid wood preservative to cut, drilled, worked surfaces.

.5 Coordinate with Section 07 52 00 and Section 07 62 00 for installation of modified bitumen membrane roofing and associated metal flashings.

.6 At sandbox install filter fabric and waterproofing membrane where shown and fill box with play sand to 100 mm below top of perimeter curb. Install turn buttons for tarp at locations matching grommets.

.7 Paint all hot dip galvanized steel surfaces with epoxy primer and 2 coats of aliphatic polyurethane paint in accordance with Section 09 97 13.

.8 Apply stain to all exposed wood surfaces as follows:

.1 One coat of semi-transparent stain at all locations except Type 3 fence.

.2 At Type 3 fence provide 2 coats of solid colour stain by Sikkens in colour selected by Consultant

.9 Install fence gate hardware in accordance with respective manufacturer's directions. Provide the following:

.1 Two hinges for each gate leaf.

.2 One lockable gate latch for each gate.

.3 One cane bolt complete with concrete footing, sleeve and strike plate for each double leaf gate.

.10 Mount play panels on wall with concealed clip hanging system.

END OF SECTION

PART 1 GENERAL

1.1 RELATED SECTIONS

.1 Section 03 30 00 – Cast in Place Concrete - Landscape

1.2 SHOP DRAWINGS

.1 Submit shop drawings in accordance with Section 01 33 00 – Submittal Procedures.

.2 Indicate dimensions, sizes, assembly, anchorage and installation details for each furnishing specified.

1.3 CLOSEOUT SUBMITTALS

.1 Provide maintenance data for care and cleaning of site furnishings for incorporation into manual specified in Section 01 78 23 – Operation and Maintenance Data.

.2 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.

1.4 DELIVERY, STORAGE AND HANDLING

.1 All material shall be delivered to the site in a timely manner to avoid prolonged storage on site, while not delaying the work.

.2 All material shall be stored level on the site, and shall be raised off the ground, stacked with separating spacers, and covered with a water-proof material.

1.5 INSPECTION

.1 The location of the site furnishings where shown on the drawings is approximate only.

.2 Verify the actual location on site before installation and immediately report all discrepancies to the Consultant.

.3 Ensure that all surfaces on which site specialties are to be placed have been inspected and approved by the consultant.

.4 Verify the actual site locations with the consultant before installation.

.5 Give timely notice when items are ready for inspection and installation.

.6 All items shall be inspected immediately upon arrival on site for damages and integrity before installation.

.7 Perform testing of playground equipment to meet standards of CSA Z614 Standard

1.6 COORDINATION AND COOPERATION

.1 Coordinate installation of all site furnishings with other trades.

.2 Supply all items that are to be cast into work in due time as to not delay work progress.

.3 Cooperate with other trades in every possible way so as to not delay work progress.

1.7 PROTECTION

.1 Be responsible for the protection of all site furnishings that cannot be immediately installed after delivery to the site.

.2 Store such items in a designated location and protect against damages and weather.

.3 Damaged items shall not be installed and shall be immediately removed from the site

.4 Install all items as soon as possible after arrival on site, subject to Consultant's approval.

PART 2 PRODUCT

2.1 MATERIALS

.1 Bike Rack at Entrance Doors and Infant shed as supplied by Landscape Forms, p. 416 821 4710. Contact: Lee Day.
- .1 Mounting: Surface mount as per supplier's specifications
- .2 Model No.: Flo
- .3 Colour: NA
- .4 Quantity: 5

Or approved alternative

.2 Bike Rack at Street as supplied by City of Toronto, p. 416 397 0590. Contact: Lisa Ing.
- .1 Mounting: Direct Burial
- .2 Model No.: Standard City of Toronto Bike Ring
- .3 Colour: NA
- .4 Quantity: 3

Or approved alternative

.3 Infant and Toddler Planters as supplied by Equiparc, p. 800 363 9264 x238. Contact: Patrick Maheux
- .1 Mounting: Bolt Anchored
- .2 Model No.: EP 4981
- .3 Colour: Douglas Fir wood covering, Meteor Grey Structure
- .4 Quantity: 2

Or approved alternative

.4 Streetscape Benches as supplied by Equiparc, p. 800 363 9264 x238. Contact: Patrick Maheux
- .1 Mounting: Bolt Anchored
- .2 Model No.: EP 1051
- .3 Colour: Ipe wood top, Metallic Silver base
- .4 Quantity: 3

Or approved alternative

.5 Streetscape Tree Guards as supplied by Canaan Site Furnishings. 1 877 305 6638 Contact: Anna Liu
- .1 Mounting: as per suppliers specifications
- .2 Model No.: CAG-107
- .3 Colour: RAL 7040
- .4 Quantity: 2

Or approved alternative

.6 Rectangular Planters on 2nd floor terrace as supplied by Green Theory. 604 475 7002. Contact: Brandon Babock
- .1 Mounting: Not anchored
- .2 Model No.: Civilian, PP1273.48
- .3 Size: 48” x 15” x 19”
- .4 Material: Fibreglass
- .5 Colour: Smoky Beige
- .6 Quantity: 5
- .7 Bottom to have 6 x 1” drainage holes drilled and lined with filter fabric prior to container soil being added.

Or approved alternative

.8 Parking bollards
- .1 Custom fabricated T-316 alloy stainless steel bollards manufactured from 5” (127mm) diameter tubing with a wall thickness of 6 mm. Top end of bollard closed. Unit is equipped with a lower base (Undercarriage) to be imbedded into the concrete foundation. Contact Lars S. Hermanson, Nelson Industrial Inc., tel. 800.277.6897.
- .2 Quantity: 5 – w/ sign on 2 piece galv. sign post
- .3 Height (gross): 1340 mm (890 mm visible after pouring of concrete paving)
- .4 Mounting: fasteners, anchors by installing Contractor
- .5 Finish: Satin brush

PART 3 EXECUTION

3.1 INSTALLATION

.1 Assemble pre-manufactured furnishings and accessories in accordance with manufacturer's instructions and detail drawings.

.2 Assemble equipment in accordance with manufacturer’s specifications and in compliance with CSA standards.

.3 Install furnishing true, plumb, and firmly anchored as per drawings and/or manufacturer’s recommendations.

.4 Touch-up minor scratches to approval of the Consultant.

.5 Protect site furnishings from damage and vandalism until date work is certified as substantially performed in accordance with General Conditions of the project

.6 Damaged furnishings will be rejected.

3.2 Erection of Site Furnishings

.1 Examination

.1 Examine the site prior to starting erection and report any discrepancies to the consultant a minimum of two days prior to starting work. Do not proceed unless surfaces are acceptable.

.2 Commencement of installation will denote acceptance of surfaces and failure of furnishings due to defective surfaces will be rectified at no cost to the Owner.

.2 General

.1 Install site furnishings level and straight, and fasten securely to base as per drawings and/or manufacturer's recommendations.

.2 Layout work installed by this section carefully to accommodate requirements of other sections.

.3 Fitting into place

.1 Brace work temporarily as required to maintain safety in place.

.4 Quality Verification

.1 Provide adequate notice to the consultant as to the timing of the work so that field review of the preparation work can be undertaken prior to find installation

.5 Protection after Completion

.1 Be responsible for protection of all site specialties until inspection, approval and acceptance of all project work.

.2 Repair all damages and do all remedial work as requested at no extra cost.

3.3 TESTING

.1 Inspection and testing will be required of all materials and works as called for in the technical specification sections and is the responsibility of the Contractor. The testing Consultants will be required to provide quality control of the Work and all materials incorporated into the Work to ensure compliance of the work with the requirements of the drawings, details and construction specifications.

3.4 CSA Inspections and Compliance

.1 Test safety surfacing by an Independent Testing Consultant in accordance with the Engineered Wood Safety Surfaces specifications. Organize and schedule the work of this section to permit the testing to occur without delays and under normal conditions. Playground inspection cost is the responsibility of the Contractor.

.2 The Contractor is to coordinate all parties well in advance as to the required time for attendance at the site, in order to complete the mandatory reviews to allow for the orderly, uninterrupted prosecution of the Work within the time specified for completion. The Contractor shall abide by all site review recommendations and make any necessary site adjustments as deemed necessary.

3.5 CONTRACTOR / PLAY EQUIPMENT SUPPLIER CSA INSPECTIONS AND COMPLIANCE

.1 Upon completion of the playground and site works and prior to the equipment being commissioned for use, both the Contractor and the Supplier shall inspect the playground site in accordance with all the requirements for final inspection of the CAN/CSA-Z614-07. Correct any deficiencies that may be found contrary to the CSA Standard.

.2 The contractor shall perform the safety surface testing in accordance with ASTMF 355 and ASTMF 1292.

.3 Acceptable Play Inspection and testing agents are:
- .1 Reliable Reporting. Attn: Scott Belair, Phone: (416) 580-5437
- .2 Playscape Inspection and Consulting Services Inc., Attn: John Zandarin, Phone: (416) 691 5437

3.6 PLAYGROUND CERTIFICATION FORM:

.1 When playground fully passed its inspection and testing, the Contractor / Supplier shall sign, seal and date a Playground Certification Form and submit to Consultant.

END OF SECTION

1 General

1.1 **CONFORMANCE**

.1 The General Conditions are part of this Section and shall apply as if written herein.

1.2 **SCOPE OF WORK**

.1 Placement and grading of imported topsoil to levels and dimensions as per drawings or instructions of Landscape Architect.

.2 Placing and grading of topsoil produced from stripping of existing soil to levels and dimensions as per drawings or instructions of Landscape Architect.

1.3 **SUBMITTALS**

.1 Submit in accordance with section 01 33 00 – Submittal Procedures.

.2 Submit two (2) copies of soil analysis and recommendations for corrections to Owner.

1.4 **SCHEDULING**

.1 Schedule placing of topsoil to permit sodding and planting operations under optimum conditions.

1.5 **PROTECTION**

.1 Prevent damage to fencing, railing, posts, trees, landscaping, bench marks, existing pavement and surface or underground utility lines which are to remain. Make good any damage.

2 Products

2.1 **SOURCE QUALITY CONTROL**

.1 Acceptance of imported topsoil subject to inspection and soil analysis test results. Do not commence work until topsoil accepted.

.2 Inspection and testing of topsoil to be carried out by testing laboratory.

.3 Test topsoil from source prior to stockpiling, for clay, sand and silt, percentage and particle size, dry density, NPK, Mg, soluble salt content, pH value, growth inhibitors, soil sterilants, organic material, trace elements.

.1 Use 25mm (1") diameter sampling tube or spade and in presence of Owner take 20 samples from topsoil stockpile at random locations. Mix samples together thoroughly before submitting for testing.

.2 Submit .5 kg. sample of topsoil to testing laboratory and indicate present use, intended use, type of subsoil and quality of drainage. Prepare and ship sample in accordance with provincial regulations and testing laboratory requirements.

.3 Determine required limestone treatment to bring pH level of soil to 6-7.

2.2 **MATERIALS**

.1 Topsoil: Use local topsoil and amend it to establish a suitable growing medium for planting and sodding, free from subsoil, roots, noxious weeds, debris, toxic materials, and stones over 50mm (2") diameter. Topsoil to have a pH value of 6-7 and organic matter of 3-4%. Amend soil with following items as directed by soils report and test results and specific plant material. Imported topsoil -- a triple mix with pH value of 6-7 and organic matter of 3-4%.

.2 Loam: Sandy loam topsoil.

.3 Compost: Processed organic matter containing 40% or more organic matter as determined by the Walkley-black or LOI test. Decayed leaf or mushroom compost as available by Gro Bark, All Treat Farms or Grower's Choice or approved equal. Compost shall be free of metals and glass or other unacceptable materials for planting use. Product must be sufficiently decomposed (i.e. stable) so that any further decomposition does not adversely affect plant growth.

.4 Manure: Well-rotted, unbleached cattle manure; free from harmful chemicals and other injurious substances, and sawdust, shavings or similar refuse; at least eight (8) months old, but not more than two (2) year old; and with no more that 25% straw, leaves, or other unacceptable materials for planting use.

.5 Pine Bark Compost: Decomposed pine bark mulch with or without Perlite as available from Gro Bark, All Treat Farms or Grower's Choice or approved equal.

.6 Pine Bark Mulch: Finely Shredded Pine bark mulch as available from Gro Bark, All Treat Farms or Grower's Choice or approved equal.

.7 Peatmoss: Derived from partially decomposed sphagnum mosses; brown in colour, elastic and homogeneous with shredded particle sizes of minimum 5mm, free of wood and deleterious material which could prohibit plant growth.

.8 Bonemeal: Raw, commercial, finely ground and with a minimum content of 4% nitrogen and 20% phosphoric acid.

.9 Fertilizer:

.1 Complete commercial fertilizer, 50% of the elements of which shall be derived from organic sources, and containing no less than 60% urea-formaldehyde with percentages by weight of nitrogen, phosphoric acid, and potash required to make up chemical deficiencies of soil and as required by plant growth and noted in soil test results.

.2 Incorporate finely ground commercial superphosphate with a minimum analysis of 20% phosphorous (v) oxide.
.3 Acid Fertilizer 15-5-10, pH level 5.5 – 6.5 .

3 Execution

3.1 **PREPARATION**

.1 Remove soil contaminated with toxic materials. Dispose of removed materials as directed by Owner. Do not perform work under adverse field conditions such as frozen soil, excessively wet soil, ice, or standing water.

.2 Cultivate entire area which is to receive topsoil to depth of 100mm (4"). Repeat cultivation in those areas where equipment use for hauling and spreading has compacted soil.

.3 Remove and dispose of weeds; debris; stones 40mm in diameter and larger; soil contaminated by oil, gasoline and other deleterious materials; as directed by Landscape Architect or Landscape Architect.

3.2 **SPREADING OF TOPSOIL/PLANTING SOIL**

.1 Spread topsoil after Landscape Architect has inspected subgrade.

.2 Spread topsoil with adequate moisture in uniform layers over approved, unfrozen subgrade, where sodding and planting indicated.

.3 For sodded areas keep topsoil 12mm (1/2") below finished grade.

.4 Apply topsoil as indicated to following minimum depths:
.1 100mm (4”) Sodded areas.
.2 150mm (6") for seeded areas.
.3 500mm for trees and large shrubs.
.4 400mm for groundcovers.

3.3 **SOIL AMMENDMENTS**

.1 Apply soil amendments at rate as specified and as determined from soil sample test. Start laying sod at bottom of slopes.

.2 Mix soil amendments into full depth of topsoil prior to application of fertilizer.

3.4 **APPLICATION OF FERTILIZER**

.1 Spread fertilizer uniformly over entire area of topsoil at manufacturer's recommendation rate of application.

.2 Mix fertilizer thoroughly to full depth of topsoil.

.3 Add Fertilizer no later than June.

END OF SECTION

1 General

1.1 **SUMMARY**

.1 Section Includes:
.1 Materials and installation for plant material, accessories, mulch, planting, tree support, mulching and maintenance.

1.2 **REFERENCES**

.1 Agriculture and Agri-Food Canada (AAFC).
.1 Plant Hardiness Zones in Canada-[2000].

.2 Canadian Nursery Landscape Association (CNLA).
.1 Canadian Standards for Nursery Stock 8th Edition.

1.3 **DEFINITIONS**

.1 Mycorrhiza: association between fungus and roots of plants. This symbiosis, enhances plant establishment in newly landscaped and imported soils.

1.4 **SUBMITTALS**

.1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit product data for:
.1 Fertilizer.
.2 Mycorrhiza.
.3 Anti-desiccant.
.4 Mulch.

.3 Submit samples for:
.1 Mulch.
.2 Mycorrhiza.

1.5 **SOURCE QUALITY CONTROL**

.1 Supplier - The Consultant reserves the right to request that a synopsis of the company and its responsible officers be submitted for Owner’s approval.

.2 Supply and deliver Products such as fertilizer and mulches, in standard containers clearly indicating contents, weight, analysis and name of manufacturer. If products are supplied in bulk, submit written statements indicating above information.

.3 Make all material available for inspection at source of supply and notify Consultant at least seven days in advance of shipment. No work in this section is to proceed without approval.

.4 Acceptance of plant material at its source does not prevent rejection on site prior to or after planting operations.

.5 Plant Material: True to genus, species and variety having normal growth habit; structurally sound, well branched, healthy densely foliated when in leaf and with healthy and well-developed root system.

.6 Supply and deliver Products such as fertilizer and mulches, in standard containers clearly indicating contents, weight, analysis and name of manufacturer. If products are supplied in bulk, submit written statements indicating above information.

.7 Imported plant material must be accompanied with necessary permits and import licenses. Conform to federal and provincial regulations. Submit inspection certificates as required from Federal, provincial and/or other regulatory agency.

.8 Do not substitute plants without written submitted proof that specified plants or sizes are unobtainable.

.9 Do not remove labels from plants until plants have been inspected and approved by the Consultant.

.10 Conform to Horticultural standards of the Canadian Nursery Trades Association with respect to grading and quality. Supply in accordance to the plant list.

.11 Coordinate shipping of plants and excavation of holes to ensure minimum time laps between digging and planting.

1.6 **STORAGE AND PROTECTION**

.1 Protect plant material from frost, excessive heat, wind and sun during delivery.

.2 Immediately store and protect plant material that will not be installed within 1 hour after arrival at site in storage location approved by Consultant.

.3 Protect plant material from damage during transportation:
- .1 When 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 When delivery distance exceeds 30 km or vehicle travels at speeds over 80 km/h, use enclosed vehicle where practical.
- .3 Protect foliage and root balls using anti-desiccants and tarpaulins, where use of enclosed vehicle is impractical due to size and weight of plant material.

.4 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.

.3 For balled and burlapped and wire basket root balls, place to protect branches from damage. Maintain moisture level in root zones.

.5 Store and manage hazardous materials in accordance with local Municipal and Provincial Regulations.

.6 Waste Management and Disposal:
- .1 Separate waste materials for reuse and/or recycling.
- .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 in accordance with Spec 01 74 19 Construction Waste Management.
- .4 Separate for reuse and/or recycling and place in designated containers for Steel, Metal, Plastic waste in accordance with Spec 01 74 19 Construction Waste Management.
- .5 Place materials defined as hazardous or toxic in designated containers.
- .6 Handle and dispose of hazardous materials in accordance with National, Provincial, Regional and Municipal regulations.
- .7 Divert unused metal materials from landfill to metal recycling facility as per municipal regulations.
- .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 plastic recycling facility approved as per Municipal regulations.
- .10 Dispose of unused fertilizer at official hazardous material collection site as per Municipal regulations.
- .11 Dispose of unused anti-desiccant at official hazardous material collections site as per Municipal regulations.
- .12 Divert unused wood and mulch materials from landfill to appropriate recycling or composting facility as per Municipal regulations.

1.7 SCHEDULING

.1 Obtain approval from Consultant of schedule 7 days in advance of shipment of plant material.

.2 Schedule to include:
- .1 Quantity and type of plant material.
- .2 Shipping dates.
- .3 Arrival dates on site.
- .4 Planting Dates.

1.8 WARRANTY & ACCEPTANCE

.1 The CONTRACTOR hereby warrants that the WORK shall be completed in a timely fashion, and in a good workmanlike and tidy manner, and guarantee the

work against all defects in workmanship, materials, and against death of plant materials for a period of two years following issuance of Preliminary Acceptance Certificate. Any defects arising during the said period shall be remedied forthwith by the CONTRACTOR to the satisfaction of the Consultant. At the request of the OWNER and the CONTRACTOR will assign to the OWNER or enforce on behalf of the OWNER all guarantees obtained by the CONTRACTOR with respect to the work.

.2 The final date for Preliminary Acceptance in each calendar year is October 31. If the CONTRACTOR is unable to complete the work by that date, Preliminary Acceptance will not be scheduled until the spring of the following year and the two (2) year warranty will not commence until Preliminary Acceptance has been received. The CONTRACTOR will maintain the work until that time at no extra cost to the OWNER. End-of-warranty inspection will be conducted by Consultant.

.3 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.

.4 All irrigation to be done manually by contractor for duration of establishment: 2 years. Client to maintain manual irrigation only after establishment.

2 Products

2.1 **PLANT MATERIAL**

.1 Type of root preparation, sizing, grading and quality: comply with Canadian Standards for Nursery Stock.
- .1 Plant material must be planted in zone indicated as appropriate for its species.
- .2 Plant material in location appropriate for its species.

.2 Plant material:
- .1 Sound, healthy, vigorous, well branched and densely foliated when in leaf, free of disease, insects, defects or injuries and structurally sound with strong, well-developed fibrous root system.
- .2 Freshly dug and in healthy condition at arrival on site. Heeled in plants or plants from cold storage will not be accepted. Whenever possible supply plants from the same hardiness zone and having the same soil characteristics as area of site.
- .3 Conform to measurements specified in plant list, except that plant lists larger than specified may be used if acceptable to the Consultant without increase in Contract Price. If larger plants are accepted increase earth ball in proportion to size of plant.

.3 Stems: free of sunscalds, frost cracks, abrasions, fire and crust, with old injuries completely calloused over. Pruning wounds: showing vigorous bark on edges and parts with live, green cambium tissue.

.4 Trees: with straight trunks, well and characteristically branched for species except where specified otherwise.

.5 Trees larger than 200mm in calliper: half root pruned during each of two successive growing seasons, the latter at least one growing season prior to arrival on site.

.6 Bare root stock: nursery grown, in dormant stage, not balled and burlapped or container grown.

.7 Collected stock: maximum 40mm in calliper, with well developed crowns and characteristically branched; no more than 40% of overall height may be free of branches.

.8 Material - Should the Contractor proceed to use material that is not shown on the approved planting plan and plant list, the Consultant shall proceed to have such works corrected at the Contractor's expense.

.9 Substitutions - Must be approved in writing by the Consultant

2.2 **SOIL**

.1 Topsoil: Fertile, friable natural loam containing 4% minimum organic matter; acidity range from pH 6.0 to 7.5 and capable of sustaining vigorous plant growth; free of admixture of subsoil, lumps, stones and roots over 25mm diameter and other extraneous matter and reasonably free of weeds, weed seeds and rhizomes.

.2 Container Soil in large planters on Roof: Boulevard Mix as supplied by Gro-Bark Ont. Ltd., P.O. Box 453, Waterloo, N2J 4A0, (519) 885-3411 or approved equal.

.3 Container Soil in small rasied planters on roof top and playground: Gro-Max Premium Garden Soil as supplied by Gro-Bark Ont. Ltd., P.O. Box 453, Waterloo, N2J 4A0, (519) 885-3411 or approved equal.

2.3 **BONEMEAL**

.1 Commercial, raw bonemeal, finely ground and with minimum analysis of 2% nitrogen and 11% phosphoric acid

2.4 **LIME**

.1 Where pH of topsoil is less that 6.0, 8% minimum of calcium and magnesium carbonates combined, finely ground to pass #10 mesh sieve. Rate of application: Selected after determining pH of topsoil

2.5 **WATER**

.1 Free of impurities that would inhibit plant growth.

2.6 **WRAPPING MATERIAL**

.1 First quality burlap or heavy duty waterproof crepe paper.

.2 Wrapping only acceptable for transport, wrapping to be removed on site.

2.7 **TRUNK PROTECTION**

.1 Plastic: perforated spiralled strip.

.2 Burlap: clean, minimum 2.5 kg/m^2 mass and 150 mm wide, and twine fastener.

.3 Rodent guards to be installed on all deciduous trees

2.8 **MULCH**

.1 Trees and Plant Beds (not in rubber) – shredded pine mulch (SPM) or shredded well-decayed compost with oak leaf content not greater than 30% or Coloured Seasoned Pine or Enhance Black Bark.

.2 Colour: Black

.3 Wood Chip mulch collected from tree removal operation will not be accepted.

.4 All mulch as supplied by Gro-Bark Ont. Ltd., P.O. Box 453, Waterloo, N2J 4A0, (519) 885-3411 or Grower's Choice Kitchener, (519) 896-9459 or All Treat Farms, (519) 848-3145.

2.9 **FERTILIZER**

.1 Complete commercial fertilizer, 50% of the elements of which shall be derived from organic sources, and containing no less than 60% urea-formaldehyde with percentages by weight of nitrogen, phosphoric acid and potash required to make up chemical deficiencies of soil and as required by plant growth.

.2 Incorporate finely ground commercial superphosphate with a minimum analysis of 20% phosphorous (v) oxide.

.3 Slow release fertilizers are to be used in case of late fall plantings.

2.10 **ANTI-DESICCANT**

.1 Wax-like emulsion permeable enough to permit transpiration and delivered, missed and applied in accordance with manufacturer's recommendations.

2.11 **FLAGGING TAPE**

.1 Fluorescent, red/orange colour.

2.12 **SOURCE QUALITY CONTROL**

.1 Obtain approval from Consultant of plant material prior to planting.

.2 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 in accordance with Section 01 35 25 – Safety.

.2 Ensure plant material acceptable to Consultant.

.3 Remove damaged roots and branches from plant material.

.4 Apply anti-desiccant to conifers and deciduous trees in leaf in accordance with manufacturer's instructions.

.5 Before excavating, ascertain location of electrical cables, conduits, utility lines, supply lines and sub-surface drainage. If such items are uncovered or if subsurface debris is uncovered, notify Consultant and obtain instructions before relocating plant material or moving obstructions.

.6 Within the Area of Concern for ALHB (Asian Long Horned Beatle), the Contractor shall provide the following information to the Consultant a minimum of two weeks prior to commencement of the work:

.1 The Name, Address and Location of the Nursery that will be supplying plant materials for the contract.

.2 Written confirmation that the Contractor has notified the Area Office of the Canadian Food Inspection Agency (CFIA) about the proposed host tree removals and a description of CFIA’s response and any action taken.

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 and obtain approval from Consultant prior to excavating.
.2 If planting drainage is required, specify requirements.
.3 Excavate to depth and width as indicated.
.4 Remove subsoil, 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 off site.
.5 Scarify sides of planting hole.
.6 Remove water that enters excavations prior to planting. Notify Consultant if water source is ground water.
.7 Backfill planting beds and tree pits with soil mixture consisting of 4 parts topsoil to one part LiveMulch Low PH.
.8 Add bonemeal to soil at rate of 0.6 kg/m3.
.9 Mix topsoil soil mixture, Low PH LiveMulch and other additives thoroughly on site 2 days maximum before backfilling.
.10 Do not mix or backfill when topsoil is in muddy or frozen condition.
.11 Backfill to height above finished grade sufficient to allow for normal, natural settlement.
.12 Finish grade, after settlement: As shown on Contract Documents
.13 Tamp each layer firmly before placing subsequent layers to ensure the absence of air pockets.

3.3 PLANTING

.1 For bare root stock, place 50mm 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 150mm lifts. Tamp each lift to eliminate air pockets. When 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 Space vertical cut to perimeter of planting hole very 150-200mm for the complete diameter of planting hole.

.6 For ground covers, backfill soil evenly to finish grade and tamp to eliminate air pockets.

.7 Water plant material thoroughly.

.8 After soil settlement has occurred, fill with soil to finish grade.

.9 Dispose of burlap, wire and container material off site.

3.4 TRUNK PROTECTION

.1 Trunk protection shall be only be used during transport.

.2 Install polypipe rodent guards on al deciduous trees.

3.5 MULCHING

.1 Spread Mulch in planting beds and around trees to a minimum depth of 100mm.

.2 Groundcover and Perennials Area – Shredded Compost spread to min. 60mm

3.6 MAINTENANCE DURING WARRANTY PERIOD

.1 From time of acceptance by 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 If required to control insects, fungus and disease, use appropriate control methods in accordance with Federal, Provincial and Municipal regulations. Obtain product approval from 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 Remove and replace dead plants and plants not in healthy growing condition. Make replacements in same manner as specified for original plantings.
- .12 The Contractor shall not be responsible for the cost of replacements resulting from theft, vandalism, carelessness or neglect on the part of others or any other causes due to circumstances beyond his control.
- .13 Submit monthly written reports to 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.

.14 All irrigation to be done manually by contractor for duration of establishment:2 years. Client to maintain manual irrigation only after establishment.

3.7 VERIFICATION

.1 Contractor's Verification, include:
- .1 Materials and resources.
- .2 Storage and collection of recyclables.
- .3 Construction waste management.
- .4 Local/regional materials.

END OF SECTION

1 - General

1.1 SUMMARY

A. Section Includes:
   1. Silva Cell system for planting and paving, including Silva Cell assemblies and related accessories.
   2. Other materials including, but not limited to, geotextile, geogrid, aggregate, subbase material, backfill, root barrier, and planting soil.

B. Related Requirements:
   1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
   2. Section 01 33 00 - Submittal Procedures: For administrative and procedural requirements for processing of submittals during the construction phase.
   3. Section 01 70 00 – Contract Closeout: For administrative and procedural requirements for completion of the Work

1.2 REFERENCES

A. Definitions:
   1. AGGREGATE BASE COURSE: Aggregate material between the paving and the top of the Silva Cell deck below, designed to distribute loads across the top of the deck.
   2. AGGREGATE SETTING BED FOR PAVERS: Aggregate material between the aggregate base course and unit surface pavers, designed to act as a setting bed for the pavers.
   3. AGGREGATE SUBBASE: Aggregate material between the bottom of the Silva Cell base and the compacted subgrade below, designed to distribute loads from the Silva Cell bases to the subgrade.
   4. BACKFILL: The earth used to replace or the act of replacing earth in an excavation beside the Silva Cell system to the excavation extents.
   5. FINISH GRADE: Elevation of finished surface of planting soil or paving.
   6. PLANTING SOIL: Soil as defined in Division 32, Section 32 94 56 - Planting Soil for Silva Cells, intended to fill the Silva Cell system and other planting spaces.
   7. SILVA CELL SYSTEM:
      a. Silva Cell: One assembled unit made up of 1 base, 6 post assemblies, and 1 Silva Cell deck.
      b. Silva Cell System: Two or more Silva Cells used in combination with each other and with required accessories.
   8. SUBGRADE: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill.
   9. WALK-THROUGH: A process for light compaction of soils by walking through the soil following placement.

B. Reference Standards:

   1. ASTM International (ASTM):

a. ASTM D448-12, Standard Classification for Sizes of Aggregate for Road and Bridge Construction
b. ASTM D698-12e1, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 [600 kN-m/m^3])
c. ASTM D1241-07, Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses
d. ASTM D3786/D3786M-13, Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
e. ASTM D4491-99a(2014)e1, Standard Test Methods for Water Permeability of Geotextiles by Permittivity
f. ASTM D4533-D4533M-15, Standard Test Method for Trapezoid Tearing Strength of Geotextiles
g. ASTM D4632-D4632M-15, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
h. ASTM D4751-12, Standard Test Method for Determining Apparent Opening Size of a Geotextile
i. ASTM D4833/D4833M-07(2013)e1, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
j. ASTM D5262-07(2012), Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
k. ASTM D6241-14, Standard Test Method for Static Puncture Strength of Geotextile and Geotextile-Related Products Using a 50mm Probe
l. ASTM D6637-11, Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

2. Ontario Provincial Standard Specification (OPSS)

1.3 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Conference: Prior to installation of the Silva Cell system and associated Work, meet with the Contractor, Silva Cell system installer and their field supervisor, manufacturer's technical representative, the Consultant, the Owner at the Owner's discretion, and other entities concerned with the Silva Cell system performance.
   1. Provide at least 72 hours advance notice to participants prior to convening preinstallation conference.
   2. Introduce and provide a roster of individuals in attendance with contact information.
   3. The preinstallation conference agenda will include, but is not limited to the review of:
      a. Required submittals both completed and yet to be completed.
      b. The sequence of installation and the construction schedule.
      c. Coordination with other trades.
      d. Details, materials and methods of installation.
         1) Review requirements for substrate conditions, special details, if any, installation procedures.
         2) Installation layout, procedures, means and methods.

      e. Mock-up requirements.

B. Sequencing and Scheduling:
   1. General: Prior to beginning Work of this Section, prepare a detailed schedule of the Work involved for coordination with other trades.

2. Schedule utility installations prior to beginning Work of this Section.
3. Where possible, schedule the installation of the Silva Cell system after the area is no longer required for use by other trades and Work. Where necessary to prevent damage, protect installed system if Work must occur over or adjacent to the installed Silva Cell system.

1.4 SUBMITTALS

A. Action Submittals: Submit these to the Consultant for review and acceptance not less than 45 days prior to start of installation of materials and products specified in this Section.
   1. Product Data: For each type of product, submit manufacturer's product literature with technical data sufficient to demonstrate that the product meets these specifications.
   2. Test and Evaluation Reports:
      a. Submit results of compaction testing required by the Specifications for approval.
      b. Include analysis of bulk materials including soils and aggregates, by a recognized laboratory that demonstrates that the materials meet the Specification requirements.

   3. Samples:
      a. One full size sample of an assembled Silva Cell (copy of manufacturers brochure with images of product may be accepted in lieu of actual sample).
      b. One 6-inch (150-mm) square piece of geogrid.
      c. One 6-inch (150-mm) square piece of geotextile.

   4. Manufacturer's Report: Submit Silva Cell system manufacturer's letter of review and approval of the Project, including Drawings and Specifications, Addenda, Clarifications and Modifications, and for compliance with product installation requirements.
   5. Qualification Statements:
      a. Manufacturer:
         1) Submit list of completed projects demonstrating durability and longevity of in-place systems.
            a) Include project name, location, and date of completion.
         2) Submit list of third party approval for stormwater management projects.

      b. Installer:
         1) Submit documentation of the qualifications of the Silva Cell system installer and their field supervisor, sufficient to demonstrate that both meet the requirements specified in Article 1.05 QUALITY ASSURANCE.
         2) Submit list of completed projects of similar scope and scale demonstrating capabilities and experience.

B. Closeout Submittals: Submit these to the Consultant at completion of installation.
   1. Warranty: Submit manufacturer's warranty, fully executed.

1.5 QUALITY ASSURANCE

A. Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, Provincial and Municipal authorities having jurisdiction. Obtain necessary permits/approvals from these authorities.

B. Manufacturer Qualifications:
   1. A manufacturer whose product is manufactured in an ISO/TS 16949 compliant and ISO 9001 - 2008 registered factory.
   2. A manufacturer with not less than 100 Silva Cell systems in-place, each system in use for not less than 7 years, confirming durability and longevity of the system.
   3. A manufacturer with documented written approval of their product for use as a stormwater treatment device by a minimum of 3 governmental jurisdictions.
   4. A manufacturer with an established and demonstrated utility service and repair process, including written procedure and photographs demonstrating work.
   5. A manufacturer with a published operating and maintenance manual

C. Installer Qualifications: A qualified installer with not less than 5 years of successful experience installing Silva Cell systems or related products and materials, and whose work has resulted in successful installation of underground piping, chambers and vault structures, planting soils, and planter drainage systems of a similar scope and scale in dense urban areas.

D. Installer's Field Supervisor: A full-time supervisor employed by the installer with not less than 5 years of successful experience similar to that of the installer and present at the Project site when Work is in progress. Utilize the same field supervisor throughout the Project, unless a substitution is submitted to and approved in writing by the Consultant.

E. Mock-Up: Prior to the installation of the Silva Cell system, construct a mock-up of the complete installation at the Project site in the presence of the Consultant.
   1. Size and Extent: Minimum of 100 sq. ft. (9.29 sq. m.) in area and including the complete Silva Cell system installation with subbase, aggregate subbase, drainage installation, Silva Cell decks, posts, and bases, base course aggregate, geotextile, geogrid, backfill, planting soil, and necessary accessories.
   2. The mock-up area may remain as part of the installed Work at the end of the Project provided that it remains undamaged and meets the requirements of the Drawings and Specifications.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Silva Cell System: Protect Silva Cell system components from damage during delivery, storage and handling.
   1. Store components on smooth surfaces, free from dirt, mud and debris. Store under tarp to protect from sunlight when time from delivery to installation exceeds one week.
   2. Perform handling with equipment appropriate to the size (height) of Silva Cells and site conditions; equipment may include, hand, handcart, forklifts, extension lifts, or small cranes, with care given to minimize damage to Silva Cell bases, posts, decks and adjacent assembled Silva Cells.

B. Packaged Materials: Deliver packaged materials in original, unopened containers indicating weight, certified analysis, name and address of manufacturer, and indication

of conformance with Provincial and Federal laws, if applicable. Protect materials from deterioration during delivery and while on the Project site.

C. Bulk Materials:
   1. Do not deliver or place backfill, soils, or soil amendments in frozen, wet, or muddy conditions.
   2. Provide protection including tarps, plastic and/or matting between bulk materials and finished surfaces sufficient to protect the finish material.
   3. Bring planting soil to the site using equipment and methods that do not overly mix and further damage soil peds within the soil mix.

D. Provide erosion-control measures to prevent erosion or displacement of bulk materials and discharge of soil-bearing water runoff or airborne dust to adjacent properties, water conveyance systems, and walkways. Provide additional sediment control to retain excavated material, backfill, soil amendments and planting mix within the Project limits as needed.

1.7 FIELD CONDITIONS

A. Existing Conditions: Do not proceed with Work when subgrades, soils and planting soils are in a wet, muddy or frozen condition.

1.8 WARRANTY

A. The Contractor shall warrant the Silva Cell system to be free of faults and defects in accordance with the General Conditions, except that the warranty shall be extended by manufacturer's written warranty against defects in materials and workmanship as follows:
   1. DeepRoot® warrants to the original purchaser of its Silva Cell™ product that such product will be free from defects in materials and workmanship, and perform to DeepRoot's written specifications for the warranted product, when installed and used as specifically provided in the product's installation guidelines for a period of 20 years from the date of purchase. This warranty does not cover wear from normal use, or damage caused by abuse, mishandling, alterations, improper installation and/or assembly, accident, misuse, or lack of reasonable care of the product. This warranty does not apply to events and conditions beyond DeepRoot's control, such as ground subsidence or settlement, earthquakes and other natural events, acts of third parties, and/or Acts of God. If this warranty is breached, DeepRoot® will provide a replacement product. Incurred costs, such as labor for removal of the original product, installation of replacement product, and the cost of incidental or other materials or expenses are not covered under this warranty.
   2. Deeproot® makes no other warranties, express or implied, and specifically disclaims the warranty of merchantability or fitness for a particular purpose. Deeproot® shall not be liable either in tort or in contract for any direct, incidental or consequential damages, lost profits, lost revenues, loss of use, or any breach of any express or implied warranty.

2 - Products

2.1 MANUFACTURER

A. Acceptable Manufacturers:

DeepRoot Green Infrastructure, LLC
101 Montgomery Street, Suite 2850
San Francisco, CA, 94104

415.781.9700
800.458.7668
Fax 415.781.0191

www.deeproot.com

B. Substitutions: Manufacturers seeking approval of their products are required to comply with the spec 01 26 00 Contract Modification Procedures.

2.2 DESCRIPTION

A. The term Silva Cell shall be used to refer to a single Silva Cell.
B. Silva Cells shall be designed for the purpose of growing healthy trees and providing stormwater management.
C. Silva Cells shall be modular, structural systems.
D. Each Silva Cell shall be structurally-independent from all adjacent Silva Cells for incorporating utilities and other site features as well as for future repairs.
E. Silva Cells shall be capable of supporting loads up to and including CSA-S6 87.5 kN (Canada) when used in conjunction with approved pavement profiles.
F. Silva Cells shall be open on all vertical faces and horizontal planes and shall have no interior walls or diaphragms.
G. Silva Cells shall be capable of providing a large, contiguous, continuous volume of planting soil that does not inhibit or prevent the following:
    1. Placement of planting soil
    2. Walk through compaction
    3. Compaction testing of planting soil, once in place
    4. Movement and growth of roots
    5. Movement of water within the provided soil volume, including lateral capillary movement
    6. Installation and maintenance of utilities placed within, adjacent to, or below the Silva Cell.

H. Silva Cells shall be able capable of being filled with a variety of soil types and soils that include peds 2 inches (50 mm) or larger in diameter as is appropriate for the application, location of the installation, and tree species.

2.3 SILVA CELL MATERIALS AND ACCESSORIES

A. Silva Cell System Components: Each "Silva Cell 2" soil cell module (hereafter Silva Cell or "cell") is composed of one base, 6 post assemblies, and one deck.

1. 3x Silva Cell 2 System:
    a. Components: One base, six 3x posts (a combination of six 1x posts and six 2x posts), and one deck.

b. Assembled Dimensions (Each Cell): 47.2 inches long by 23.6 inches wide by 43 inches high (1200 mm long by 600 mm wide by 1092.2 mm high).

B. Silva Cell Materials and Fabrication:
1. Bases and Posts: Homopolymer polypropylene.
2. Decks: Fiberglass reinforced, chemically-coupled, impact modified polypropylene.

C. Manufacturer's Related Silva Cell Installation Accessories:
1. Strongbacks: An accessory designed to stabilize the Silva Cell posts temporarily, during soil placement, and removed for reuse prior to placing decks.
2. Anchoring Spikes: 10” landscape spike for securing assembled Silva Cells to subbase.

D. Water and Air System 02:
1. Deeproot Stainless Steel Grate (Swivels) in stainless steel.
2. Water + Air System with adjustable heights in cast aluminum.

2.4 RELATED PRODUCTS

A. Root Barrier: Recyclable, black, injection molded panels manufactured with a minimum 50 percent post-consumer recycled polypropylene plastic with UV inhibitors, and integrated zipper joining system which allows instant assembly by sliding one panel into another; for redirecting tree roots down and away from hardscapes.
1. Panel Sizes:
a. No. UB12-2: 24 inches long by 12 inches deep by 0.080 inches thick (61 cm long by 30 cm deep by 2.03 mm thick); for use with 1x systems and for pavement profiles less than 12 inches (30 cm) deep.
b. No. UB18-2: 24 inches long by 18 inches deep by 0.080 inches thick (61 cm long by 46 cm deep by 2.03 mm thick); for use with 2x and 3x systems, and for pavement profiles 12 inches or more in depth.

2. Products meeting this specification:
a. DeepRoot Tree Root Barrier (DeepRoot Green Infrastructure, LLC)

B. Geogrid: Net-shaped woven polyester fabric with PVC coating, uniaxial or biaxial geogrid, inert to biological degradation, resistant to naturally occurring chemicals, alkalis, and acids; used to provide a stabilizing force within soil structure as the fill interlocks with the grid .
1. Tensile strength at ultimate (ASTM D6637): 1850 lbs/ft (27.0 kN/m) minimum
2. Creep reduced strength (ASTM D5262): 1000 lbs/ft (14.6 kN/m) minimum
3. Long term allowable design load (GRI GG-4): 950 lbs/ft (13.9 kN/m) minimum
4. Grid aperture size (MD): 0.8 inch (20 mm) minimum
5. Grid aperture size (CD): 1.28 inch (32 mm) maximum
6. Roll size: 6-foot (1.8-m) width is preferred, up to 18-foot (5.4-m).

7. Products meeting this specification:
a. Stratagrid SG 150; http://www.geogrid.com
b. Miragrid 2XT; http://www.tencate.com
c. Fortrac 35 Geogrid; (http://www.hueskerinc.com
d. SF 20 Biaxial Geogrid; http://www.synteen.com

C. Geotextile: composed of high tenacity polypropylene yarns which are woven into a network such that the yarns retain their relative position and is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.

1.	Tensile strength at ultimate (ASTM D4595):	5100 lbs/ft (74.4 KN/m) MD minimum 5100 lbs/ft (74.4 KN/m) CD minimum
2.	Tensile strength at 2% strain (ASTM D4595):	960 lbs/ft (14.0 KN/m) MD minimum 1560 lbs/ft (22.8 KN/m) CD minimum
3.	Tensile strength at 5% strain (ASTM D4595)	2400 lbs/ft (350 KN/m) MD minimum 3600 lbs/ft (52.5 KN/m) CD minimum
4.	Tensile Strength at 10% (ASTM D4595):	5040 lbs/ft (73.5 KN/m) MD minimum
5.	Factory Seam Strength (ASTM 4884):	3000 lbs/ft (43.8 KN/m) minimum
6.	Flow rate (ASTM D4491):	30 gal/min/ft^2 (2648 l/min/m^2) minimum
7.	Apparent opening size (ASTM D4751):	30 sieve (0.60 mm)
9.	UV Resistance (at 500 hours):	80 percent strength retained

10. Products meeting this specification:
    a. Mirafi HP570; http://www.tencate.com
    b. Geolon PP40; http://www.tencate.com
    c. Nilex Woven 2044 (Nilex); http://www.nilex.com

D. Plastic Cable Ties: A tensioning device or tool used to tie similar or different materials together with a specific degree of tension.

2.5 OTHER RELATED MATERIALS

A. Wood Blocking: Nominal dimensioned untreated lumber used for spacing assembled Silva Cells.
B. Drain and Distribution Pipes:
60mm Solid PVC pipe
60mm Perforated pipe
100mm perforated pipe
100mm Solid PVC pipe
C. Aggregate Subbase (Below Silva Cell Base):
1. Aggregate meeting one of the following specifications:

a. Complying ASTM D1241, Type I, Gradation B; Type I mixtures shall consist of stone, gravel, or slag with natural or crushed sand and fine mineral particles passing a No. 200 sieve.

Sieve	Percent Passing
1-1/2 inches (37.5 mm)	100
1 inch (25 mm)	75 to 95
3/8 inch (9.5 mm)	40 to75
No 4 (4.75 mm)	30 to 60
No 10 (2 mm)	20 to 45
No 40 (425 µm)	15 to 30
No 200 (75 µm)	5 to 15

b. Local Department of Transportation (DOT) virgin aggregate that most closely meets the gradation of ASTM D1241.

c. Ontario Provincial Standard Specification (OPSS) 1010 Granular A. Dense graded aggregates intended for use as granular base within the pavement structure, granular shouldering, and backfill.

Sieve	Percent Passing
26.5 mm	100
19 mm	85 to100
13.2 mm	65 to90
9.5 mm	50 to73
4.75 mm	35 to55
1.18 mm	15 to 40
300 µm	5 to 22
75 µm	2 to 8

D. Aggregate Base Course (Above Silva Cell Deck):
1. Same as aggregate subbase specified above.

E. Aggregate Base Course for Porous Pavement (Above Silva Cell Deck):
1. Aggregate complying with ASTM D448, No. 57.

Sieve	Percent Passing
1-1/2 inches (37.5 mm)	100
1 inch (25 mm)	95 to 100
1/2 inch (12.5 mm)	25 to 60
No 4 (4.75 mm)	0 to 10
No 8 (2.36 mm)	0 to 5

F. Setting Bed for Unit Pavers (Above Silva Cell Deck):
1. Aggregate complying with ASTM D448, No. 8.

Sieve	Percent Passing
1/2 inch (12.5 mm)	100
3/8 inch (9.5 mm)	85 to 100
No 4 (4.75 mm)	10 to 30
No 8 (2.36 mm)	0 to 10
No 16 (1.18 mm)	0 to 5

G. Backfill Material (Adjacent to Silva Cells): Clean, compactable, coarse grained fill soil free of organic material, trash and other debris, and free of toxic material injurious to plant growth.
H. Planting Soil: Refer to Section 32 94 56 - Planting Soil for Silva Cells.

3 - Execution

3.1 EXAMINATION

A. Examine the conditions under which the Silva Cells are to be installed.
   1. Carefully check and verify dimensions, quantities, and grade elevations.
   2. Carefully examine the Drawings to become familiar with the existing underground conditions before digging. Verify the location of aboveground and underground utility lines, infrastructure, other improvements, and existing trees, shrubs, and plants to remain including their root system.
   3. Notify the Contractor and the Consultant in writing in the event of conflict between existing and new improvements, of discrepancies, and other conditions detrimental to proper and timely completion of the installation.
   4. Obtain written approval of changes to the Work prior to proceeding. Proceed with installation only after changes have been made and unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Take proper precautions as necessary to avoid damage to existing improvements and plantings.
B. Prior to the start of Work, layout and stake the limits of excavation and horizontal and vertical control points sufficient to install the complete Silva Cell system.
C. Coordinate installation with other trades that may impact the completion of the Work.

3.3 TEMPORARY PROTECTION

A. Protect open excavations and Silva Cell system from access and damage both when Work is in progress and following completion, with highly visible construction tape, fencing, or other means until related construction is complete.
B. Do not drive vehicles or operate equipment over the Silva Cell system until the final surface material has been installed.

3.4 EXCAVATION

A. General: Excavate to the depths and shapes indicated on the Drawings. Provide smooth and level excavation base free of lumps and debris.
B. Confirm that the depth of the excavation is accurate and includes the full section of materials required to place the subbase aggregate, Silva Cell, and pavement profile as indicated on the Drawings.
C. Over-excavate beyond the perimeter of the Silva Cell to allow for:
   1. The extension of aggregate subbase beyond the Silva Cell layout as shown on the Drawings.
   2. Adequate space for proper compaction of backfill around the Silva Cell system.

D. If unsuitable subgrade soils are encountered, consult the Owner's geotechnical consultants for directions on how to proceed.
E. If conflicts arise during excavation, notify the Consultant in writing and make recommendations for action. Proceed with Work only when action is approved in writing.

3.5 SUBGRADE COMPACTION

A. Compact subgrade to a minimum of 95 percent of maximum dry density at optimum moisture content in accordance with ASTM D698, Standard Proctor Method, or as approved by the Owner's geotechnical representative.
B. Do not exceed 10 percent slope for subgrade profile in any one direction. If the 10 percent slope is exceeded, contact manufacturer's representative for directions on how to proceed.

3.6 INSTALLATION OF GEOTEXTILE OVER SUBGRADE

A. Install geotextile over compacted subgrade.
   1. Lay geotextile flat with no folds or creases.
   2. Install the geotextile with a minimum joint overlap of 18 inches (450 mm).

3.7 INSTALLATION OF AGGREGATE SUBBASE BELOW SILVA CELL BASES

A. Install aggregate subbase to the depths indicated on the Drawings.
B. Extend subbase aggregate a minimum of 6 inches (150 mm) beyond the base of the Silva Cell layout.
C. Compact aggregate subbase to a minimum of 95 percent of maximum dry density at optimum moisture content in accordance with ASTM D698, Standard Proctor Method.
D. Do not exceed 10 percent slope on the surface of the subbase. Where proposed grades are greater than 10 percent, step the Silva Cells to maintain proper relation to the finished grade.

3.8 INSTALLATION OF SILVA CELL BASE

A. Install the Silva Cell system in strict accordance with manufacturer's instructions and as specified herein; where requirements conflict or are contradictory, follow the more stringent requirements.
B. Layout and Elevation Control:
   1. Provide layout and elevation control during installation of the Silva Cell system to ensure that layout and elevations are in accordance with the Drawings.

C. Establish the location of the tree openings in accordance with the Drawings. Once the trees are located, mark the inside dimensions of the tree openings on the prepared subbase.
D. Locate and mark other Project features located within the Silva Cell layout (e.g. light pole bases, utility pipes). Apply marking to identify the extent of the Silva Cell layout around these features. Follow the layout as shown on the Drawings to ensure proper spacing of the Silva Cell bases. Refer to the Drawings for offsets between these features and the Silva Cells.
E. Check each Silva Cell component for damage prior to placement. Reject cracked or chipped units.

F. Place the Silva Cell bases on the compacted aggregate subbase. Start at the tree opening and place Silva Cell bases around the tree openings as shown on the Drawings.
G. Working from tree opening to tree opening, place Silva Cell bases to fill in the area between tree openings.
   1. Maintain spacing no less than 1 inch (25 mm) and no more than 6 inches (150 mm) apart, assuming geotextile covering the decks meets the specifications in section 2.04 paragraph C.
H. Follow the Silva Cell layout plan as shown on the Drawings.
I. Install Silva Cell bases around, over, or under existing or proposed utility lines, as indicated on the Drawings.
J. Level each Silva Cell base as needed to provide full contact with subbase. Adjust subbase material, including larger pieces of aggregate, so each base sits solidly on the surface of the subbase. Silva Cell bases that rock or bend over any stone or other obstruction protruding above the surface of the subbase material are not allowed. Silva Cell bases which bend into dips in the subbase material are not allowed. The maximum tolerance for deviations in the plane of the subbase material under the bottom of the horizontal beams of each Silva Cell base is 1/4 inch in 4 feet (6 mm in 1200 mm).
K. Anchor Silva Cell base with 2 spikes per base.
   1. For applications where Silva Cells are installed over waterproofed structures, use wood blocking or similar spacing system consistent with requirements of the waterproofing system to maintain required spacing.

3.9 INSTALLATION OF SILVA CELL POSTS

A. 3x Silva Cell 2 System:
   1. Attach 2x posts to the installed Silva Cell base. Each base will receive six 2x posts. Place the end of the post with tabs into the base. Rotate post clockwise to snap in place.
   2. Following the placement of backfill and planting soil within the 2x posts, add a 1x post extension as described herein. A 2x post, used in combination with a 1x post is considered a 3x post assembly.

3.10 INSTALLATION OF STRONGBACKS, GEOGRID, BACKFILL AND PLANTING SOIL

A. For Silva Cell systems that have a perforated drain line located inside or adjacent to the system, consult Drawings for layout and details.
B. Install strongbacks on top of the Silva Cell posts by snapping into place over installed posts prior to installing planting soil and backfill.
   1. Strongbacks are required only during the placement and compaction of the planting soil and backfill.
   2. Move strongbacks as the Work progresses across the installation.
   3. Remove strongbacks prior to the installation of the Silva Cell decks.

C. Install geogrid around the perimeter of the Silva Cell system where the compacted backfill and planting soil interface.
   1. Do not place geogrid between the edge of the Silva Cells and adjacent planting areas.
   2. Cut the geogrid to allow for a 6-inch (150-mm) overlap at the Silva Cell base and a 12-inch (300-mm) overlap at the Silva Cell deck.
   3. Provide a minimum 12-inch (300-mm) overlap between adjacent sheets of geogrid.

4. Secure geogrid with cable ties below the top of the posts, along the post ridges.

D. Place the first lift of backfill material loosely around the perimeter of the Silva Cell system, between the geogrid and the sides of the excavation. Place backfill to approximately the midpoint of the Silva Cell post. Do not compact.
E. Place the first lift of planting soil in the Silva Cell system to approximately the midpoint of the Silva Cell post.
   1. Level the planting soil throughout the system.
   2. Walk-through the placed planting soil to remove air pockets and settle the soil. Do not compact greater than 80 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method.

F. Compact the first lift of backfill material, previously spread, to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method or in accordance with Project Specifications for hardscape areas, whichever is greater.
G. Add and compact additional backfill material so that the final finished elevation is at approximately the same level of the placed planting soil within the Silva Cells.
   1. Maintain the geogrid between the Silva Cell system and the backfill material at all times.

H. Place the second lift of backfill material loosely around the perimeter of the Silva Cell system, between the geogrid and the sides of the excavation so that the material is 2 to 3 inches below the top of the posts. Do not compact.
I. Place the second lift of planting soil inside of the Silva Cell to the bottom of the strongbacks. Walk through.
J. Remove strongbacks, place one 1x posts into each of the previously-installed 2x posts. Rotate clockwise to snap in place, forming a 3x post assembly.
K. Immediately reinstall strongbacks on top of the post assembly.
L. Repeat process of alternately placing backfill and planting soil so that elevation of the compacted backfill and the walked-through planting soil are just below the level of the strongbacks.

3.11 INSTALLATION OF IRRIGATION AND WATER HARVESTING SYSTEM

A. Install irrigation and water harvesting system in accordance with the Drawings and Specifications. Remove only the minimum number of strongbacks needed to accommodate the Work and reinstall them immediately upon completion to maintain alignment of posts.

3.12 INSTALLATION OF SILVA CELL DECK

A. Obtain final approval by the Consultant of planting soil installation prior to installation of the Silva Cell decks.
B. Remove strongbacks, level out the planting soil, and immediately install decks over the posts below. Place deck over the top of the posts. Push decks down until the deck clips lock into the posts, snapping the deck into place.
C. Fold the 12 inches (300 mm) of geogrid onto the top of the decks.

3.13 FINAL BACKFILL PLACEMENT AND COMPACTION

A. Place and compact final lift of backfill material to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method, such that the backfill is flush with the top of the installed deck. Do not allow compacting equipment to come in contact with the decks.

3.14 INSTALLATION OF GEOTEXTILE AND AGGREGATE BASE COURSE OVER THE DECK

A. Ensure geotextile meets the specifications in section 2.04 paragraph C.
B. Place geotextile over the top of the deck and extend to the edge of the excavation. Overlap joints a minimum of 18 inches (450 mm). Leave enough slack in the geotextile for the aggregate base course to push the geotextile down in the gaps in between the decks.
C. Install the aggregate base course (including aggregate setting bed if installing unit pavers) over the geotextile immediately after completing the installation of the fabrics. Work the aggregate from one side of the layout to the other so that the fabric and aggregate conform to the Silva Cell deck contours.
D. Maintain equipment used to place aggregate base course completely outside the limits of the Silva Cell excavation area to prevent damage to the installed system.
E. For large or confined areas, where aggregate cannot easily be placed from the edges of the excavated area, obtain approval for the installation procedure and types of equipment to be used in the installation from the Silva Cell manufacturer.
F. Compact aggregate base course(s) to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method. Utilize a vibration or plate compactor with a maximum weight of 800 lbs (362.87 kg).
G Do not drive vehicles or operate equipment over the completed aggregate base course.

3.15 INSTALLATION OF CONCRETE CURBS AT TREE OPENINGS, AGGREGATE SUBBASE AND PAVEMENT ABOVE THE SILVA CELL SYSTEM

A. Place concrete curbs along planting areas and tree openings as shown on the Drawings to retain the aggregate base course from migrating into the planting soil.
B. When staking concrete forms (e.g. curbs around the tree openings), prevent stakes from penetrating the Silva Cell decks.
C. Turn down edge of concrete paving to the Silva Cell deck along the edges of tree openings or planting areas to retain the aggregate base course material.
D. When paving type is a unit paver or other flexible material, provide a concrete curb under the paving at the edge of the Silva Cell deck to retain the aggregate base course material at the tree opening.
E. Place paving material over Silva Cell system in accordance with the Drawings.
    1. The Silva Cell system does not fully meet loading strength until the final paving is installed. Do not operate construction equipment on top of the Silva Cell system until paving installation has been completed.

F. Use care when placing paving or other backfill on top of Silva Cell system to prevent damage to the Silva Cell system or its components.

3.16 INSTALLATION OF ROOT BARRIERS

A. Install root barrier in accordance with manufacturer's installation instructions.

3.17 INSTALLATION OF PLANTING SOIL WITHIN THE TREE PLANTING AREA

A. Remove rubble, debris, dust and silt from the top of the planting soil within the tree opening that may have accumulated after the initial installation of the planting soil within the Silva Cells.
B. Install additional planting soil within the tree openings, to the depths indicated on the Drawings.
   1. Use the same soil used within the Silva Cells for planting soil within the tree openings.

C. Compact planting soil under the tree root ball to between 85 and 90 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method, to prevent settlement of the root ball.
D. Place trees in accordance with the Drawings.

3.18 PROTECTION

A. Keep construction traffic away from the limits of the Silva Cells until the final pavement profile is in place. The Silva Cell system does not fully meet loading strength until the final paving is installed.
   1. Do not operate equipment directly on top of the Silva Cell system until paving installation has been completed.
   2. Provide fencing and other barriers to prevent vehicles from entering into the Silva Cell area.

B. When the Silva Cell installation is completed and the permanent pavement is in place, limit traffic and construction related activities to only loads less than the design loads.

3.19 CLEAN UP

A. Perform clean up during installation and upon completion of the Work. Maintain the site free of soil, sediment, trash and debris. Remove excess soil materials, debris, and equipment from the site following completion of the Work of this Section.
B. Repair damage to adjacent materials and surfaces resulting from installation of this Work using mechanics skilled in remedial work of the construction type and trades affected.

END OF SECTION

1 - General

1.01 SUMMARY

A. Section Includes:

1. Labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, and delivery of planting soil and /or the modification of existing site soil for use as planting soil within the Silva Cell system.

B. The scope of Work in this Section includes, but is not limited to, the following:
1. Locate, purchase, deliver and install imported planting soil and soil amendments.
2. Harvest and stockpile existing site soils suitable for planting soil.
3. Modify existing stockpiled site soil.

C. Related Requirements:

1. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 0I Specifications, apply to Work of this Section.
2. Section 01 33 00 – Submittal Procedures: For administrative and procedural requirement for processing of submittals during the construction phase.
3. Section 01 77 00 – Closeout Procedures: For administration and procedural requirements for completion of the Work.
4. Section: 32 93 10 Planting
5. Section: 32 94 51 Silva Cells

1.02 REFERENCES

A. Definitions:
1. COMPACTION: The density of soil measured as oven dry weight divided by volume.
2. EXISTING SOIL: Mineral soil existing at the locations of proposed planting of area designated for the installation of Silva Cells after the majority of the construction within and around the planting or Silva Cell site is completed and just prior to the start of Work to excavate the soil
3. CONSULTANT: The person or entity, employed by the Owner to represent their interest in the review of the Work.
4. PED: Clump or clod of soil held together by a combination of clay, organic matter, and fungal hyphae, retaining the original structure of the harvested soil.
5. SCREENED SOIL: Soil that has been processed through a metal screen to remove or break apart soil peds (clumps /clods), roots, rocks and debris and remove larger physical items in the soil not permitted by the specification.
6. SILVA CELLS: Structural paving support system defined in Section **32 94 51** Silva Cells.
7. SUBGRADE: Surface or elevation of subsoil remaining after completing excavation, or top surface of fill or backfill, before placing planting soil.

B. Reference Standards:

1. ASTM International (ASTM)
   a. ASTM C33, Standard Specification for Concrete Aggregates- Fine Aggregates.
2. The Soil Science Society of America.
   a. Methods of Soil Analysis, most current edition,

1.03 SUBMITTALS

A. Action Submittals: Submit these to the Consultant for review and acceptance not less than 45 days prior to start of installation of materials and products specified in this Section.

1. Product Data: For each type of product, submit manufacturer's product literature with technical data sufficient to demonstrate that the product meets these specifications.
   a. For each compost product submit the manufactures certification that the compost meets the requirements for US Compost Council STA/TMECC criteria for “Compost as a Landscape Backfill Mix Component” and other requirements of the Specification.
   b. For coarse sand product submit the following analysis by a recognized laboratory:
      1) pH
      2) Manufactures Fines Modulus Index
      3) Particle size distribution (percent passing the following sieve sizes):

3/8 inch	(9.5 mm)
No 4	(4.75 mm)
No 8	(2.36 mm)
No 16	(1.18 mm)
No 30	(0.60 mm)
No 50	(0.30 mm)
No 100	(0.15 mm)
No 200	(0.075 mm)

2. Test and Evaluation Reports:
   a. Include analysis of bulk materials including soils and aggregates, by a recognized laboratory that demonstrates that the materials meet the Specification requirements.
   b. Submit required soil test analysis report for each sample of imported topsoil, existing site soil, and planting soil mixes from an approved soil-testing laboratory as follows:
      1) Do not submit planting soil mixes, for testing until all topsoil, compost, and coarse sand have been approved,
      2) If tests fail to meet the Specifications, obtain other sources of material, retest and resubmit until accepted by the Consultant.
      3) All testing shall be performed following the requirements of *Methods of Soil Analysis*, The Soil Science Society of America.
      4) Provide a particle size analysis (percent dry weight) and USDA soil texture analysis. Soil testing of planting soil mixes shall also include USDA gradation distribution of gravel, coarse sand, medium sand, and fine sand in addition to silt and clay. Reports of partical size distribution shall use USDA size nomenclature and analysis protocols.
      5) Provide the following other soil properties:

a.) pH and buffer pH.
b.) Percent organic content by oven dried weight.
c.) Nutrient levels by parts per million including: phosphorus, potassium, magnesium, manganese, iron, zinc and calcium. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the soil for optimum growth of the plantings specified.
d.) Soluble salt by electrical conductivity of a 1:2 soil water sample measured in Milliohm per cm.

6) All soil testing will be at the expense of the Contractor.

3. Samples:
   a. Each sample shall be double bagged packaged in two plastic zip loc style bags. Each bag shall be clearly marked with the project name, date, contractors name and telephone number, and product name.
   b. Samples of all existing site soil, topsoil, coarse sand and, compost and planting soil mixes shall be submitted at the same time as the particle size and physical analysis of that material.
   c. Samples of the existing site soil that are under existing pavement to be removed may be submitted as soon as possible after the paving is removed.
   d. Samples will be reviewed for appearance only.
   e. Provide samples for the following products.
      1) One-gallon (3.79-liter) sample of each type of existing site soil prior to adding amendments.
      2) One-gallon (3.79-liter) sample of imported topsoil.
      3) One-gallon (3.79-liter) sample of bio-retention topsoil.
      4) One-gallon (3.79-liter) sample of compost.
      5) One-gallon (3.79-liter) sample of bio-retention compost.
      6) One-gallon (3.79-liter) sample of coarse sand.
      7) One-gallon (3.79-liter) sample of unscreened planting soil mix.
      8) One-gallon (3.79-liter) sample of screened planting soil mix.
      9) One-gallon (3.79-liter) sample of bio-retention soil mix.
4. Qualification Statements:
   a. Soil supplier:
      1) Submit documentation of the qualifications of the planting soil supplier and their field supervisor, sufficient to demonstrate that both meet the requirements specified in Article 1.05 QUALITY ASSURANCE.
      2) Submit list of completed projects of similar scope and scale demonstrating capabilities and experience.

1.04 QUALITY ASSURANCE

A. Supplier: Soil mixes shall be supplied by a firm that specializes in the production of mixes of planting soils and have at least 5 years experience in providing soil mixes soils to projects of similar size and scope to this Work.
B. Soil Testing Laboratory Qualifications: The testing laboratory shall specialize in agricultural soil testing and be a member of the Soil Science Society of America's, North American Proficiency Testing Program (NAPT). Testing results for soil particle size shall be reported using USDA sizes for sand, silt, and clay.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Weather: Do not mix or deliver soil when frozen or muddy.
B. Protect soil and soil stockpiles, from wind, rain and washing that can erode soil or separate fines and coarse material, and contamination by chemicals, dust and debris that may be detrimental to plants or soil drainage. Confine delivered materials to neat piles in areas coordinated with the site supervisor. Cover stockpiles with plastic sheeting or fabric at the end of each Workday.
C. All manufactured packaged products and material shall be delivered to the site in unopened containers and stored in a dry enclosed space suitable for the material and meeting all environmental regulations.
    1. Biological and chemical additives shall be protected from extreme humidity, cold, or heat. All products shall be freshly manufactured and dated for the year in which the products are to be used. Chemical amendments shall have original labels intact and legible, stating the guaranteed chemical analysis.

PART 2 - PRODUCTS

2.01 EXISTING SITE SOIL

A. Existing site soil: Soil at the site including the possibility of subgrade soil under existing paving that is of a texture and chemical composition that can support roots provided that compost and or fertilizer is added and the soil compaction loosened.
B. Existing site soil shall meet the following criteria:
    1. Soil objects larger than 1/4 inch (6.24 mm) in diameter: Existing site soil shall contain less than 5 percent total volume of the combination of all objects 1 to 8 inches (25 mm – 200 mm) in their largest dimension including clumps/clods of heavy clay, sandy clay or silty clay subsoil, debris, refuse, roots, stones, sticks, brush, and or litter. The soil shall contain less than 8 percent by volume total of the above objects 1/4 inch (6.24 mm) to 1 inch (25 mm) in diameter. Remove objects larger than 8 inches (200 mm) in its longest dimension.

    2. Seedlings that germinated from seeds in the soil shall be removed within one month of germination whether during the period the soil is being stored or after installation including during the plant warranty period.

    3. The Consultant shall verify that the soil in the designated areas is suitable at the beginning of planting bed preparation Work. The decisions to specify the use of existing site soils is based on assumptions made during the design phase about the quality of soil which may have been covered by paving at that time or where construction activity earlier in the Project may have altered this soil.

    4. Soil testing results and soil observation notes that describe the preconstruction soil conditions in the existing soil areas are included as an appendix to this Specification:

C. If the Consultant determines the soil to be unacceptable or the Work of this Project has damaged areas designated for use as existing site soil to the point where the soil is no longer suitable to support the plants specified, the Consultant may require modification

of the damaged soil up to and including removal and replacement with soil of equal quality to the soil that existed prior to construction.

1. Examples of damage include further compaction, contamination, grading, creation of hardpan or drainage problems, or lack of previously assumed O, A and or B-horizon soils.
2. Do not begin Work on additional modifications or soil replacement until changes, if any, to the Contract price are approved.

D. Protect existing soil from contamination, and degradation during the construction process.

E. Excavation and storage of existing site soil:

1. Remove existing plants, roots, stumps, paving, and non-soil debris from the surface layers of the soil.

2. Excavate the soil over the areas and depths indicated on the plan or as directed by the Consultant. Utilize techniques and equipment that retains peds (clumps/clods) of soil.

3. During the excavation process, soils in the approved areas and depths of different color and texture should be loosely mixed to create a more uniform single soil while still retaining soil peds (clumps/clods). The Consultant request that soils encountered that are not in accordance with the soil assumptions not be included in the mixing process. Such soils should be removed from the site or may be used as fill soils if approved by the Consultant.

4. Do not screen the soil unless approved in advance by the Consultant. Encountered volumes of soil that do not meet the requirement for soil objects larger than 1/4 inch (6.24 mm) in diameter should be segregated during the excavation process and removed from the site. If approved, soil may be screened through a 2-inch (50 mm) square or larger opening in order to allow the soil to meet the requirements. Isolated large objects shall be removed from the soil by hand.

5. Stockpile the soil in locations approved in advance by the General Contractor.
   a. Store soil in bulk trash dumpsters with rear access doors if no suitable space exists at the site.

F. Amending existing site soil:

1. Amendments for existing site soil should be calculated for a composite mix of all soils to be used.

2. Add compost to existing site soil, up to 20 percent by moist volume to bring soil organic matter to a minimum of 3 percent by dry weight.
   a. Each 10 percent moist volume of added compost is assumed to raise the percent dry weight soil organic matter by 1.5 percent.
   b. Spread compost over the stockpile in amounts that achieve the required organic matter content. As soil is being scooped from the pile to bring to the Silva Cells, mix the compost loosely into the soil with the loader bucket. Add additional compost to the stockpile as the Work progresses to achieve even compost distribution within the mix.
   c. Do not over mix the soil. Maintain as many large soil peds (clumps/clods) as possible in the mix.

3. Add fertilizer of the types and quantity recommended by the soil test at the time of mixing.

G. Submittal Requirements: Provide a one-gallon (3.79-liter) sample of each type of of existing site soil prior to adding amendments with testing data that includes recommendations for compost volumes and chemical additives for the types of plants to be grown. Samples and test samples shall represent the composite mixing of the available soils. Samples and testing data shall be submitted at the same time.

2.02 IMPORTED TOPSOIL

A. Imported topsoil: Fertile, friable soil loam topsoil suitable for the germination of seeds and the support of vegetative growth meeting the following criteria:

1. Soil texture: USDA loam, sandy clay loam or sandy loam with clay content between 15 and 35 percent; a combined clay/silt content of no more than 60 percent; and sand between 35 and 65 percent.

2. Except where noted, imported topsoil shall NOT have been screened and shall retain soil peds (clumps/clods) larger than 2 inches (50 mm) in diameter throughout the stockpile after harvesting.
   a. Light screening through a 2-inch (50 mm) square or larger opening will be permissible in soils with clay content of 20 percent or greater if required to break up large peds (clumps/clods) or remove coarse roots and stones.
   b. Retained soil peds (clumps/clods) shall be the same color on the inside as is visible on the outside surface of the ped.

3. Soil objects larger than 1/4 inch (6.24 mm) in diameter: Imported topsoil shall contain less than 5 percent total volume of the combination of all objects 1 to 8 inch (25 mm to 200 mm) in their largest dimension including clumps/clods of heavy clay, sandy clay or silty clay subsoil, debris, refuse, roots, stones, sticks, brush, and or litter. The soil shall contain less than 8 percent by volume total of the above objects 1/4 inch to 1 inch (6.24 mm to 25 mm) in diameter. Remove all objects larger than 8 inch (200 mm) in its longest dimension.
   a. Meet the above requirement by utilizing acceptable soils sources rather than soil screening.

4. Imported topsoil may be a harvested soil from fields or development sites or purchased from suppliers who collect and process soil. The organic content and particle size distribution shall be the result of natural soil formation. Manufactured soils where sand, composted organic material or other additives have been added to the soil to meet the requirements of imported topsoil shall not be acceptable.

5. pH value shall be between 5.5 and 7.5.

6. Percent Organic Matter (OM): 3 to 5 percent, by dry weight.

7. Soluble Salt Level: Less than 2 mmho/cm.

8. Soil nutrient chemistry suitable for growing the plants specified or after

modification.

9. Germinating seedlings from seeds in the soil shall be removed within one month of germination whether during the period the soil is being stored or after installation, including during the warranty period of the plants.

B. Stockpiled existing topsoil at the site meeting the above criteria may be acceptable.

C. Submittal Requirements: Provide a one-gallon (3.79-liter) sample from each imported topsoil source with required soil testing results. The sample shall be a mixture of the random samples taken around the source stockpile or field. The soil sample shall be delivered with soil peds (clumps/clods) intact that represent the size and quantity of expected peds (clumps/clods) in the final delivered soil. The sample shall represent the expected amount of objects larger than 1/4 inch (6.24 mm).

2.03 BIO-RETENTION TOPSOIL

A. Topsoil meeting the requirements of imported topsoil and with phosphorous less than 36mg/kg (ppm) per Mehlich III test.

B. Submittal Requirements: Follow the submittal requirements for imported topsoil.

2.04 COMPOST

A. Compost: Blended and ground leaf, wood and other plant based material, composted for a minimum of 9 months and at temperatures sufficient to break down woody fibers, seeds and leaf structures, free of toxic material at levels that are harmful to plants or humans. Compost feed stock shall be yard waste trimmings, blended with other plant and or manure feed stock designed to produce compost high in fungal material.

1. Compost shall be commercially prepared compost and meet US Compost Council STA/TMECC criteria or as modified in this Section for “Compost as a Landscape Backfill Mix Component”. http://compostingcouncil.org/admin/wp-content/plugins/wp-pdfupload/pdf/191/LandscapeArch_Specs.pdf

2. Submittal Requirements: Provide one-gallon (3.79-liter) sample with manufacturer’s literature and material certification that the product meets the requirements.

2.05 BIO-RETENTION COMPOST

A. Aged triple-shredded hardwood bark or aged pine fines.
1. 1 to 3 inch (25 mm to 75 mm) typical fiber length.

B. Material shall be aged 6 months or more with dark brown color.

C. Submittal Requirements: Provide one-gallon (3.79-liter) sample with manufacturer’s literature and material certification that the product meets the requirements.

2.06 COARSE SAND

A. Clean, washed, natural sand, free of toxic materials.
   1. Coarse concrete sand, ASTM C33 Fine Aggregate, with a Fines Modulus Index of 2.8 and 3.2.

   2. Coarse sand, free of limestone, shale and slate particles. Manufactured Sand shall not be permitted.

   3. pH shall be lower than 7.4.

   4. Provide coarse sand with the following particle size distribution:

Sieve	Percent passing
3/8 inch (9.5 mm)	100
No 4 (4.75 mm)	95 to100
No 8 (2.36 mm)	80 to100
No 16 (1.18 mm)	50 to 85
No 30 (0.60 mm)	25 to 60
No 50 (0.30 mm)	10 to 30
No 100 (0.15 mm)	2 to 10
No 200 (0.75 mm)	2 to 5

B. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with manufacturer's literature and material certification that the product meets the requirements.

2.07 FERTILIZER

A. If noted by the soil test recommendations, add slow-release, organic fertilizer based on soil test and plant requirements.

B. Fertilizers should NOT be added to Bio-retention soils.

C. Submittal Requirements: Provide manufacturer's literature that the product meets the requirements.

2.08 BIOLOGICAL AMENDMENTS

A. Amendments such as Mycorrhizal additives, compost tea or other products intended to change the soil biology.

2.09 UNSCREENED PLANTING SOIL MIX

A. A mixture of imported topsoil, coarse sand, and compost to make a new soil that meets the Project goals for the indicated planting area.

   1. The approximate mix ratio of imported topsoil, coarse sand and compost shall be:

Mix component	Percent by moist volume
Imported topsoil unscreened	50 to 60 percent
Coarse sand	30 to 40 percent
Compost	10 percent

2. Final Tested Soil Organic Matter (OM): 2.75 to 4 percent (by dry weight loss ash burn).

B. Mix the coarse sand and compost together first and then add to the topsoil. Mix with a loader bucket to loosely incorporate the topsoil into the coarse sand/compost Mix. DO NOT OVER MIX. Do not mix with a soil-blending machine. Do not screen the soil. Peds (clumps/clods) of Soil, and loosely mixed Compost and coarse sand will be permitted in the overall mix.

C. At the time of soil installation, add fertilizer or biological amendments, if required, to the planting soil mix at rates recommended by the testing results for the plants to be grown.

D. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time. The sample shall be a mixture of the random samples taken around the source stockpile or field. The sample shall be delivered with soil peds (clumps/clods) intact that represent the size and quantity of expected peds (clumps/clods) in the final delivered soil mix.

2.10 SCREENED PLANTING SOIL MIX

A. A mixture of imported topsoil, coarse sand, and compost mixed off site to make a new soil that meets the Project goals for the indicated planting area.

1. A mix of imported topsoil, coarse sand and compost. The approximate Mix ratio shall be:

Mix component	Percent by moist volume
Imported topsoil screened	40 to 45 percent
Coarse Sand	40 to 50 percent
Compost	10 to 15 percent

2. Final Tested Organic Matter: 3 to 4.5 percent (by dry weight loss ash burn).

3. Final mix shall be thoroughly screened, mixed and blended.

B. At the time of soil installation, add fertilizer or biological amendments, if required, to the planting soil mix at rates recommended by the testing results for the plants to be grown.

C. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time. The sample shall be a mixture of the random samples taken around the source stockpile or field.

2.11 BIO-RETENTION SOIL MIX

A. A mixture of Un-screened imported Bio-retention topsoil, coarse sand, and bio-retention compost to make a new soil that meets the following Specification:

1. Mix proportions are based on actual amounts of sand, silt and clay in each of the 3

mix components. Adjust the proportion of each component so that the final mix, after blending, has the following ranges of particle sizes when tested using USDA testing protocol for soil particle size distribution.

Particle size	Range percent dry weight
Total Sand 0.05 to 2.0 mm	60 to 75 percent
Sand fractions 0.25 to 2.0mm	Min 55% of the above total sand
Combined silt and clay	25 to 40 percent
Allowable gravel	up to 10%

2. Final Tested Soil Organic Matter: 2.0 to 4.0 percent (by dry weight loss ash burn).

3. Final pH: between 5.5 and 7.5.

4. Phosphorus in overall mix: 12 to 36 mg/kg (ppm) per Mehlich III test.

B. Mix biochar at a rate of 5% by volume into the top 6-8 inches (152mm – 203mm) of the soil profile at the time of soil installation.

C. Mix the coarse sand and compost together first and then add to the topsoil. Mix with a loader bucket to loosely incorporate the topsoil into the coarse sand/compost Mix. DO NOT OVER MIX. Do not mix with a soil-blending machine. Do not screen the soil. Peds (clumps/clods) of Soil, and loosely mixed Compost and coarse sand will be permitted in the overall mix.

D. Submittal Requirements: Provide a one-gallon (3.79-liter) sample with testing data. Samples and testing data shall be submitted at the same time.

PART 3 - EXECUTION

3.01 INSTALLATION OF PLANTING SOIL IN SILVA CELLS

A. Refer to Section 32 94 51 - Silva Cells

END OF SECTION

1 General

1.1 **SECTION INCLUDES**

.1 Labour, Products, equipment and services necessary for foundation drainage Work in accordance with the Contract Documents.

1.2 **REFERENCES**

.1 ASTM D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

.2 ASTM F449, Standard Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control.

.3 ASTM F667, Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings.

1.3 **SUBMITTALS**

.1 Product data:
- .1 Submit manufacturer's Product data in accordance with Section 01 33 00 indicating:
  - .1 Performance criteria, compliance with appropriate reference standard(s), characteristics, and limitations.
  - .2 Product transportation, storage, handling and installation requirements.

.2 Samples:
- .1 Submit following samples in accordance with Section 01 33 00:
  - .1 Two 300 x 300 mm samples of drainage board.
  - .2 Two 300 mm long samples of perimeter drainage and/or pipe.

2 Products

2.1 **MATERIALS**

.1 Perimeter drainage:
- .1 ASTM D3350 and ASTM F667, 100 mm diameter HDPE, perforated with fittings prewrapped with filter cloth by Ideal Pipe or ‘TREMDrain Total Drain’ by Tremco Inc. or approved alternative.
- .2 Perimeter drainage system to be complete with accessories as required for complete installation including but not limited to corner guard pieces and outlet pipe connections.

.2 Drainage board: Three-dimensional dimpled core and geotextile fabric complete with adhesive or fasteners as required for installation. ‘Miradrain 6000’ by Carlisle Coatings and Waterproofing, ‘Delta-Drain 6000’ by Cosella-Dorken, ‘TREMDrain’ by Tremco Inc., or ‘Mel-Drain 5035' by W. R. Meadows.

.3 Drainage pipe (perforated and unperforated): ASTM D3350 and ASTM F667, 100 mm diameter HDPE by Ideal Pipe or approved alternative, unperforated with fittings, and perforated with fittings prewrapped with filter cloth in locations as indicated on drawings or as specified herein.

.4 Clean outs: 100 mm HDPE outlets , tees, extension pipes, reducers, flush plugs, etc. suitable for use with drainage pipe as manufactured by Canron Inc, Ideal Pipe, or approved alternative.

.5 Foundation drainage Pipe Fill: 19 mm clear stone in accordance with OPSS 1004.

.6 Granular fill: Free draining, sharp, hard, durable, granular material conforming to OPSS 1010, Type A.

.7 Filter cloth: Terrafix 270R as manufactured by Terrafix Geosynthetics Inc. or approved alternative.

3 Execution

3.1 EXAMINATION

.1 Verify condition and dimensions of previously installed Work upon which this Section depends. Report defects to Consultant. Commencement of Work means acceptance of existing conditions.

3.2 PREPARATION

.1 Verify substrate surfaces are solid, free from surface water, frozen matter, dust, oil, grease, scaling or laitance, projections and any other foreign matter detrimental to installation.

3.3 INSTALLATION

.1 Install perimeter drainage around perimeter of basement and elevator pits and where indicated on Drawings.

.2 Drainage board:

- .1 Supply and install drainage board in accordance with detailed system, and manufacturer's instructions.
- .2 Install drainage board in accordance with ASTM F449 and manufacturer's recommendations.
- .3 Drainage board shall extend full height of foundation wall to top of footing where indicated on Drawings.
- .4 Install drainage board over below grade perimeter foundation insulation as shown on Contract Drawings after installation of insulation is complete.
- .5 Position panel with flat side against wall and filter fabric toward soil/drainage side and attach to foundation wall using manufacturer approved fastening system.

.3 Provide unperforated drainage pipe between perforated drainage pipe and drain connection installed by Division 22 and 23.

.4 Install drainage pipe on a bed of foundation drainage fill, minimum 100 mm deep where pipe is not placed over footing, and surround with same fill 150 mm thick at sides and over top of pipe and for under floor drainage extend fill to under side of slab.

.5 Provide cleanouts on non-perforated pipe at all changes of direction and in pipe runs greater than 15 metres. Provide flush cleanouts where indicated.

.6 Cover foundation drainage fill with filter cloth. Cover filter cloth with sand 300 mm thick at top and sides.

END OF SECTION

1 General

1.1 SECTION INCLUDES

.1 Materials and installation for constructing sub-drains for landscape drainage with granular filter and/or geotextile filter material.

1.2 MEASUREMENT PROCEDURES

.1 Supply of sub-drain pipe will be measured in metres, of each type and size indicated and in authorized quantities delivered to designated storage area.

.2 Bedding gravel and filter material, french drain aggregate will be measured in cubic metres of material incorporated into Work. No deduction to be made for volume occupied by drain pipe.

.3 Supply and installation of pipe sub-drains will be measured in metres of each type and size installed.
- .1 Horizontal measurement will be made from centre to centre of manholes or catch basins over surface after work has been completed.
- .2 In cases where drain pipe is not connected to manholes or catch basins measurement will be actual length in place.

.4 Supply and installation of sub-drainage including, trenching, backfill, bedding, granular filter material and geotextile will be measured horizontally from manhole face to manhole face in metres of each pipe size and depth class installed.

1.3 REFERENCES

.1 American Society for Testing and Materials International, (ASTM)
- .1 ASTM C4-[02], Standard Specification for Clay Drain Tile and Perforated Clay Drain Tile.
- .2 ASTM C136-[01], Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
- .3 ASTM C444M-[95], Standard Specification for Perforated Concrete Pipe [Metric].
- .4 ASTM C654M-[99], Standard Specification for Porous Concrete Pipe [Metric].
- .5 ASTM D698-[00a], Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3(600 kN-m/m^3)).

.2 Bureau de normalisation du Québec (BNQ)
- .1 BNQ 3624-115-[2002-02-04], Polyethylene (PE) Pipe and Fittings-Flexible Corrugated Pipes for Drainage-Characteristics and Test Methods.

.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 Canadian Standards Association (CSA International)
.1 CSA B1800-[02], Plastic Non-pressure Pipe Compendium - B1800 Series (Consists of B181.1, B181.2, B181.3, B181.5, B182.1, B182.2, B182.4, B182.6, B182.7, B182.8 and B182.11).
.1 CSA B182.1-[02], Plastic Drain and Sewer Pipe and Pipe Fittings.
.2 CSA-G401-[01], Corrugated Steel Pipe Products.

1.4 SUBMITTALS

.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

.2 Inform Consultant of proposed source of bedding and filter materials and provide access for sampling prior to commencing work.

.3 Submit manufacturer's test data and certification that drain pipe materials meet requirements of this Section at least 4 weeks prior to beginning Work.

.4 Certification to be marked on pipe.

1.5 WASTE MANAGEMENT AND DISPOSAL

.1 Separate waste materials for reuse and/or recycling.

.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 in appropriate on-site bins for recycling in accordance with Waste Management Plan.

.4 Separate for reuse and/or recycling and place in designated containers: Steel, Metal, Plastic waste in accordance with Waste Management Plan.

.5 Divert all unused metals, concretes, aggregates, piping materials to appropriate recycling or disposal facilities as approved by the consultant.

.6 Fold up metal banding, flatten and place in designated area for recycling.

.7 Divert unused aggregate materials from landfill to [quarry][facility] for reuse as approved

2 Products

2.1 MATERIALS

.1 Perforated plastic pipe and fittings: to CAN/CSA B 181.2-M85 & CAN/CSA B-182.1-M83.

.2 100mm perforated PVC pipe.

.3 100mm solid PVC pipe.

.4 150mm perforated PVC pipe.

.5 150mm solid PVC pipe.

.6 Bedding gravel or crushed stone: 19mmø or 10mm clear stone as per appropriate landscape detail, to completely surround pipe.

.7 Filter cloth: R240 Filter Fabric by Terrafix or approved equal.

3 Execution

3.1 TRENCHING

.1 Do excavating, trenching and backfilling in accordance with Section 31 23 33 Excavation and Fill. Place bedding filter material after approval of excavation by Consultant.

3.2 BEDDING

.1 Pack trench with 19mm Ø clear stone.

3.3 INSTALLATION OF PIPE SUB-DRAINS

.1 Excavation: Excavate area to depths as indicated. Compact sub grade to 95% S.P.D.

.2 Pack trench with 19mm Ø clear stone.

.3 Lay drains on prepared bed true to line and grade with inverts smooth and free of sags or high points. Ensure barrel of each pipe is in contact with bed throughout full length. Commence laying at outlet and proceed in upstream direction. Lay perforated pipe with perforations downward. Make joints tight in accordance with manufacturer's instructions. Do not allow water to flow through pipes during construction except as approved. Make watertight connections to existing drain, new or existing manholes and catch basins where indicated or as directed. Plug open upstream ends of pipe with approved closures. Surround pipe with filter material and clear stone bedding material compacted to 95%. S.P.D.

.4 Install trench drain in concrete surround as indicated on Landscape drawings.

END OF SECTION